Classifying Geologic Materials, Part 1:

Goals:
1) To determine what type of observations are most useful for identifying different types of geologic samples.
2) To develop your own system of classification that can be used to describe the similarities and differences among geologic specimens.
3) To use your observations to develop hypotheses about how these samples formed.

Geology is the branch of science that focuses on studying the Earth and the materials that form our world. The first geologists began to study the earth by studying the different types of material (rocks) on the surface of our planet. In order to discuss their finding with other scientists they had to come up with a systematic way to describe, or classify, what they had found.

In this module you will examine some of the ways in which geologists classify the natural materials that Earth is made of, and you will begin this process by examining samples provided and producing your own classification system as described below.

Imagine that you are the first scientist of an alien culture to land on Earth. Your job is to describe the different geologic specimens that you have found based on their physical appearance. Your first step is to determine what properties are most useful for describing the similarities and the difference among your specimens. You will then be asked to create a classification system that can be used by you or someone else to identify and discuss these specimens and to come up with a hypothesis that explains why the rocks in one group are similar.

Pick up any two samples out of the Box labeled “Rock Sample 1” and “Rock Sample 2”

- Describe Rock Sample 1 as completely as possible (think about how you might tell someone how to find this one rock among the many rocks in this room). For example: You might describe the color of the rock as “black” (you should list at least other 5 characteristics).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Black</td>
</tr>
</tbody>
</table>
Examine Specimen 2 and compare it with Specimen 1

- Which characteristics are similar in these two samples?

- Which characteristics are different?

Samples 1 and 2 are two examples of a rock with the same chemical composition, the same arrangement of atoms, and the same formation history (in fact in may cases, they samples you’re looking at are two pieces of the same rock). Geologists would classify both of these samples as a rock called “basalt;” you’ll see samples of basalt again in later.

Most of the characteristics that both pieces of basalt share (such as their internal chemical composition) are called primary (or intrinsic) characteristics.

Primary characteristics are factors that are essential and specific to a sample; they cannot be changed without changing the chemical make up or the arrangement of atoms in a sample.

The characteristics that are different between these two rocks (such as size) are called secondary (or extrinsic) characteristics.

Secondary characteristics are characteristics that are not essential and may change with time without changing the chemical make up or the arrangement of atoms in sample.

- Identify which of the characteristics listed below are secondary (and label those with an “S”) and which are primary (label those with a “P”).

Mass/Weight on Earth: ________________  Shape: ____________

Hardness: _______  Roughness of surface: _____  Density (mass/ volume): __________

External Color (what you find on a surface that has been exposed to the atmosphere) ________

Internal color (what you would find on a fresh surface): ________

Taste (please do not test this characteristic yourself): _________

Physical state (if it is a solid, liquid, or gas) ________________

Is temperature a primary or secondary characteristic? Explain your answer.
Examine the 13 geologic samples provided (labeled A-M). Your goal is to determine how the primary characteristics of these samples differ among samples, and to use this information create a classification system that groups similar samples together. In other words, you should to create a hypothesis about which of these samples are most similar to one another (and then later, you will to speculate about why those samples are similar to one another).

**Step #1: Record your observations.** List and briefly describe how the primary characteristics of these samples differ. You should be listing at least 5 primary characteristics in addition to the example given below (note: some of the characteristics you find may not be listed above). The characteristics listed should differ among some of the samples, but they don’t have to vary among all of the samples. Don’t worry about finding a “scientific” term for what you see; just describe what you observe about how these primary characteristics of these samples differ.

<table>
<thead>
<tr>
<th>Primary Characteristic</th>
<th>Approximate Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Color</td>
<td>Light to Dark &amp; white, silver, black, pink, gold</td>
</tr>
</tbody>
</table>

Check with an instructor before you continue to make sure you understand the definition of primary characteristics.
Step #2: Use the characteristics listed above to create a unique description of each specimen. Note: you may not need to use all of the characteristics listed to describe a given sample. For example, if only one sample was purple, then listing the color as purple would distinguish it from all other samples.

Specimen A:

Specimen B:

Specimen C:

Specimen D:

Specimen E:

Specimen F:

Specimen G:

Specimen H:

Specimen I:

Specimen J:

Specimen K:

Specimen L:

Specimen M:
Step #3: Form a hypothesis about which specimens are most similar to each other. You should construct a system of classification that groups these samples so that the most similar samples are in the same group following the steps below.

Examine the specimens again and form a hypothesis about which of the characteristics you listed are most important for identifying specimens that are most similar to one another. List the characteristics below in order of decreasing important for identifying similar specimens (note: you may decide that two or more characteristics are equally important).

Most useful characteristic(s) for distinguishing among samples:

Least useful characteristic(s) for distinguishing among samples:

Explain your reasoning for choosing which characteristic(s) is the most useful.

Explain your reasoning for choosing which characteristic(s) is the least useful.
Step # 4 Describe your classification system in the space below: Physically separate the specimens on your table into different groups based on their characteristics and describe each group below. You should create your groups so that the specimens in a given group all share at least 2 primary characteristics. Each of your groups may have a different number of specimens, and you may decide that you want to create a group or groups that only contain one specimen.

<table>
<thead>
<tr>
<th>Rocks in group</th>
<th>Primary characteristics that these all these specimens share</th>
</tr>
</thead>
<tbody>
<tr>
<td>(list by specimen letter)</td>
<td></td>
</tr>
</tbody>
</table>

Check with an instructor before continuing.

Step # 5. Explain your classification system and the reasoning behind it (answer the question below).

- Which two groups of samples are the most different from each other? Describe how they differ.
Describe the specimen(s) that was the most difficult to classify. Did any specimen seem as if it might belong to more than one of the groups you have created? (Explain your answer).

How many rocks are in your largest group? Describe how the primary characteristics of the rocks in this group differ.

Step #6. Speculate about the nature of these samples.
- Suggest a valid hypothesis that explains how/why the samples in your largest group are similar to one another.

- Suggest a way to test this hypothesis (you don’t have to limit your test to the technology available in this lab).

Step #7. Share and compare your results. Compare the classification system(s) that your classmates have come up with to your own classification system by answering the questions below.

- Which group of people are you comparing your results with (list names):

- Were any sample groups you created the same or similar to the groups you created? Explain your answer.

- How did the number of sample groups they created compare with your own classification system?

- Which of the characteristics used by your classmates to distinguish between groups of samples were similar, and which were different, from the ones you used?
Classifying Geologic Materials, Part 2:

Geologists use many of the characteristics we discussed above to classify rock and minerals. A **mineral** is a naturally occurring substance formed through geological processes that has a characteristic chemical composition, a highly ordered atomic structure (called “**crystals**”) and specific physical properties. For example, quartz is a mineral made from one substance (Silica and Oxygen or SiO₂) that has a definite chemical composition. The quartz that you find in Asia has the same basic chemical make up as quartz found in Minnesota. A **rock**, by comparison, is an aggregate of minerals and need not have a specific chemical composition. For more information on crystals check out the cool videos on the following website: [http://www.classzone.com/books/earth_science/terc/content/investigations/es0506/es0506page01.cfm](http://www.classzone.com/books/earth_science/terc/content/investigations/es0506/es0506page01.cfm)

- Examine the web site “How Rocks are formed” and define the types of rocks listed below [http://www.fi.edu/fellows/payton/rocks/create/index.html](http://www.fi.edu/fellows/payton/rocks/create/index.html)

**Sedimentary Rocks**

List 3 examples of this type of Rock

**Metamorphic Rocks:**

List 2 examples of this type of Rock:

**Igneous Rocks**

List 3 examples of this type of Rock:
Click on the website for Exploring the Earth: formation of Igneous, Sedimentary, and Metamorphic Rocks (http://www.classzone.com/books/earth_science/terc/content/investigations/es0602/es0602page01.cfm) and follow the step 1-3 to answer the questions below.

➢ Describe how this website shows each type of rock forming:

Igneous Rocks:

Sedimentary Rocks:

Metamorphic Rocks:

➢ Sketch the Rock Cycle below showing the relationship between Sedimentary, Metamorphic, and Igneous Rocks.
“Igneous” rocks are the type of rocks that form when magma (molten rock) cools and crystallizes (solidifies). Volcanic eruptions take place when magma reaches the surface before it solidifies. The magma flows onto the surface as lava or erupts explosively as rapidly expanding gas propels bits of cooling lava and rock outward.

The texture of common Igneous Rocks

One important characteristic used to classify igneous rocks is their texture, or the size of their crystals.

The rocks that form from eruptions are called volcanic or extrusive igneous rocks. Volcanic rocks cool fast and thus they contain fine-grained crystal (crystals ≤ 2 mm across), in fact the individual crystals may be too small to see without a microscope.

If the magma crystallizes underground before it reaches the surface, then the magma will take a long time to solidify (because it is insulated by the overlying rocks) and the crystal that form out of the magma will be relatively large, or coarse-grained (≥ 2 mm across); these rock are called plutonic or intrusive igneous rocks.

Historical note: Vulcan was the blacksmith god of the Romans, forging the tools of the gods inside volcanoes. The word “plutonic” comes from the name “Pluto,” who was the Roman god of the underworld. Additional information of rock texture can be found at: http://geology.csupomona.edu/alert/Igneous/texture.htm

Pick up a magnifier and examine the following rocks to answer the questions listed below (Rocks = Basalt, Diorite, Gabbro, Granite, and Rhyolite).

- Which 3 rocks have large crystals (are coarse-grained)? What are the cooling histories of these rocks (intrusive or extrusive)?

- Which two rocks have small crystals (are fine-grained)? What are the cooling histories of these rocks (intrusive or extrusive)?

- Examine the sample of Andesite. This rock has a mixed texture; it has some large crystals (white) and some very small crystals (gray background). Suggest a way that this texture could have formed (what is the cooling history of this rock)?
The composition of common Igneous Rocks. The second important characteristic used to classify igneous rocks is their chemical composition. Although we don’t have an instrument to analyze the exact chemistry of these rocks, we can estimate their chemistry by looking at their color because the color of rocks vary with the amount of silica (a mixture of the element silicon and quartz) they contain. Light colored rocks generally contain more silicon.

Estimate the approximate abundance (to the nearest 5-10%) of black minerals in the following rocks.

Granite = ____%  Diorite = ____%  Gabbro = ____%

➢ Arrange the following rock in order or lightest-in-color to darkest-in-color: Andesite, Basalt, and Rhyolite.

➢ Fill in the chart below with the appropriate rock name using the size rocks listed above:

<table>
<thead>
<tr>
<th>Chemical Composition of Rock</th>
<th>Low amount of silica</th>
<th>Intermediate amount of silica</th>
<th>High Amount of Silica</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture = Intrusive (plutonic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture = Extrusive (volcanic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geologic term for chemical composition</td>
<td>Mafic</td>
<td>Intermediate</td>
<td>Felsic</td>
</tr>
</tbody>
</table>

Other types of Volcanic Rocks. Examine the samples of Obsidian and Pumice (= a volcanic rock with air bubbles that were trapped in the lava as it cooled) and answer the questions below.

➢ Describe the texture (crystal size) of these rocks and any other unusual features:

Pumice:

Obsidian:

➢ How does the density of Pumice compare to the density of water and the density of each other? What aspect of the texture of pumice explains its unusual density?
**Cascade Volcanoes.** Information about the cascade volcanoes can be found at the website of the Pacific Northwest Seismic Network’s volcano page ([http://www.pnsn.org/INFO_GENERAL/volcanoes.html](http://www.pnsn.org/INFO_GENERAL/volcanoes.html)). If you want to see a color version of the figure below, click on “Locations and 4,000 year Eruption Summary”.

![Cascade Eruptions During The Past 4,000 Years](image)

The dotted line at 200 years ago represents the start of our historic records of volcanic eruptions. Volcanic eruptions before 200 years ago are reconstructed based on geologic deposits of volcanic rocks and ash. Note: this figure does not contain any information about the relative size of each eruption. Most of the historic eruptions are relatively small events (Ex. you can scroll down to see a photo of the small ash plume erupted from Mt. Hood in 1984).

- Based on this figure, which Washington/Oregon volcano(s) besides Mt. St. Helens would you predict would be most likely to erupt next, which volcano(s) would be least likely to erupt next? Explain your reasoning.
On the Pacific Northwest Seismic Network webpage, click on the links for information about each of the Cascade Range volcanoes listed below.

<table>
<thead>
<tr>
<th>Mount Adams</th>
<th>Mount Baker</th>
<th>Crater Lake</th>
<th>Glacier Peak</th>
<th>Mount Hood</th>
<th>Mount Rainier</th>
<th>Mount St. Helens</th>
<th>Three Sisters</th>
</tr>
</thead>
</table>

At the left side of the webpage for each volcano there is a link for “Latest Earthquakes” located near each volcano. When magma moves under a volcano, it generates small earthquakes. Thus, the number of earthquakes under a volcano can be used to predict the likelihood of an eruption in the near future. In the months preceding the 1980 eruption of Mt. St. Helens there were 100s of small earthquakes under the volcano.

- Based on the latest earthquakes at these Cascade volcanoes, which volcano(es), other than Mt. St. Helens, would you predict would erupt next. Explain your reasoning.

- How do the numbers of earthquakes at this volcano compare the number of earthquakes at Mt. St. Helens in the last year and what conclusions can you draw about the relative likelihood of an eruption happening soon?

**Mt. St. Helens Ash** - These ash samples were collected after the 1980 eruption of Mt. St. Helens. When the volcano exploded, it sent a cloud of ash 1000s of feet high into the atmosphere. Winds blew the ash cloud to the east where it dropped its load of ash particles on the countryside below. Significant accumulations of ash were deposited from the Mt. St. Helen’s eruption as far away as Montana.

- Examine the samples of ash provided. How do the ash samples Ellensburg and Moses Lake differ? How can this information be used to reconstruct which location was closer to the eruption.

- Ancient ash layers frequently show up when trenches are dug through the soil and sediment in eastern Washington. Suggest what steps you could take to identify what volcano produced a given ash layer found in this way (what additional information would you want to collect).
Other volcanic risks (Mount Rainier Lahars: http://www.geotimes.org/apr04/feature_MountRainier.html)

Although it has not erupted since 1894, Mount Rainier is an active volcano and it will erupt again. In addition, large mudflows called “Lahars” can occur without warning — even in the absence of a significant eruptive event.

Lahars move at speeds up to 80 kilometers per hour, have the consistency of a wall of wet, turbulent concrete. Geologic evidence has shown that Mt. Rainier lahars as thick as 10 meters (about 30 feet) deep have buried the area under the town of Orting and other places in the river valleys around the mountain.

Lahars are classified by the U.S. Geological Survey (USGS) as the greatest hazard at Mount Rainier. For example, the city of Orting is located at the confluence of the Carbon and Puyallup rivers. The valley floor is composed of layers of deposits from old lahars. At least 60 lahars have flowed off Mount Rainier into its draining river valleys in the past 10,000 years, with the largest events occurring about every 500 years. Geologists calculate that residents of the town of Orting face a one in seven chance that a lahar will occur in their lifetimes.

In the largest known event, which occurred about 5,600 years ago, the Osceola Mudflow buried more than 540 square kilometers in a layer of debris about 8 meters (25 feet) deep. It carried as much as 4 cubic kilometers of volcanic debris 100 kilometers from the mountain. Rock debris continued flowing into the Puyallup and Kent-Auburn valleys in the following centuries — raising the level of the valley floors.

The most recent lahar occurred about 500 years ago. Called the Electron Mudflow, it swept through the Puyallup Valley, taking down trees as large as 3 meters in diameter and burying them under layers of muddy debris. Only over the past two decades, however, have geologists nailed down the present-day risk.

Mount Rainier has built up a huge edifice over time. It has grown so high, in fact, that the mountain now supports the largest system of glaciers in the lower 48 states. Starting at more than 14,000 feet elevation, the mud slurries would gain tremendous energy as they reach the valleys. And the glaciers feed the cycle that has triggered many of the large prehistoric lahars: surges of meltwater cascading from the rapid heating of snow and ice during eruptions. Not all lahars are caused by large eruptions, however. Lahars can be triggered by structural weakness due to various phenomena, including small eruptions (which may leave behind little evidence), melting snow and possibly earthquakes.

In summary: Mount Rainier’s hazards include not only the lahars from the hot rocks interacting with snow and ice like at Mount St. Helens, but also those from parts of the mountain collapsing because they’re mechanically weak. The most vulnerable section of the mountain is its western flank, leaving the Puyallup Valley most at risk from failure of weakened rock.
Based on the figure on the previous page, which rivers have the highest risk of outburst floods and lahars (note: a map with the rivers names can be found at http://vulcan.wr.usgs.gov/Volcanoes/Rainier/Maps/map_rainier_drainages.html)

Discuss the relative risk of a lahar reaching Auburn vs. reaching the town Orting.

Examine the record of outburst floods and lahars in different river valleys and speculate about why the towns of Orting and Randle have different hazard levels.