Rock Cart for Middle School Students

Time: 45 minutes
Location: Johnston Ridge Observatory – outside deck or inside visitor center
Materials: Rocks, worksheets, gray scale/texture chart, pencil, clipboards

Students will identify samples of igneous rocks and record their observations on a data sheet.

Goal:

1) Students will become familiar with igneous rocks types.
2) Students will understand that different igneous rock types have different characteristics and that these characteristics are determined by multiple factors.

Objectives:

1) Students will be able to explain what an igneous rock is.
2) Students will observe and examine physical properties, e.g. texture and color, of igneous rocks and describe the processes through which they form (7^{th} grade science benchmark – WA state).
3) Students will be able to describe the components of the earth system including the crust, mantle and core (7^{th} grade science benchmark – WA state) and their relationships to igneous rocks.
4) Students will identify rocks by their physical properties and record their observations.

Case Facts and Evidence:

1) Igneous rocks are formed by magma or lava
2) Magma is molten rock underground; lava is molten rock that has reached Earth's surface.
3) Magma is formed in the earth's mantle or where friction and pressure on a subduction zone produce heat and melt rocks.
4) Igneous rocks are differentiated by a percentage of silica
5) The amount of silica determines the shade of gray for each rock.
6) A high silica content tends reduce lava's ability to flow.
7) Igneous rocks with large crystals tend to have cooled slowly under the ground (intrusive).
8) Igneous rocks with small crystals tend to have cooled quickly above ground (extrusive).
9) Rock samples.

Volcanic Vocabulary:

1. **Igneous:** rocks formed by the cooling and crystallization of molten rock. The term **igneous** is derived from *ignius*, the Latin word for fire. Scientists have divided **igneous** rocks into two broad categories based on where the molten rock solidified: volcanic rocks (**extrusive**) which form above ground and plutonic rocks (**intrusive**) which form under ground.
2. **Intrusive:** formation of rocks below the earth's surface
3. **Extrusive:** formation of rocks at the earth's surface
4. **Minerals:** materials that make up the Earth's top layer; particles that make up a rock.
5. **Silica:** a glass-like building block of **minerals**
6. **Texture:** size, shape, and distribution of particles that make a rock
7. **Vesicular:** containing vesicles (i.e. pores in pumice)
8. **Viscous/Viscosity:** the ability of a liquid (e.g. molten rock) to resist flowing
9. **Aphanitic: Igneous** rocks composed of crystals to small to be seen without a hand lens.
10. **Phaneritic: Igneous** rocks composed of visible (to the naked eye) crystals.
11. **Porphyritic: Igneous** rocks composed of large crystals (large enough to see with the naked eye) contained in a fine-grained (to small for individual crystals to be seen) **matrix.**
12. **Matrix:** small numerous crystals, aka groundmass.

Procedure:

Identify the igneous rocks in the 'Box-O-Rox' according to distinguishing characteristics. The 'Box-O-Rox' contains numbered and lettered samples (rocks). Your group may have only one rock at a time with which to work. Observe each rock and describe it according to gray scale and texture in the corresponding square at the bottom of the page. Use the information provided by the ranger and the gray scale/texture chart to identify eight rocks.

Sample #____ Gray Scale: _____________ Texture: ________________ Identity: _________________	Sample #____ Gray Scale: _____________ Texture: ________________ Identity: _________________
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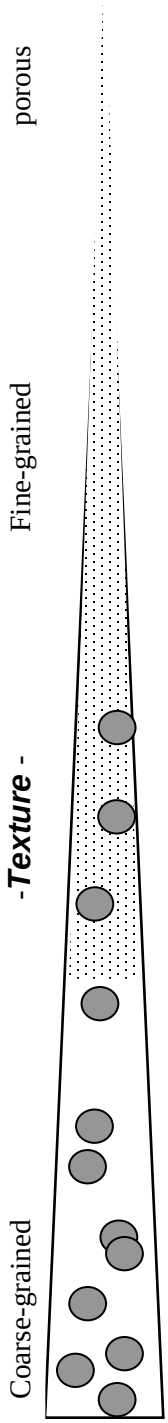
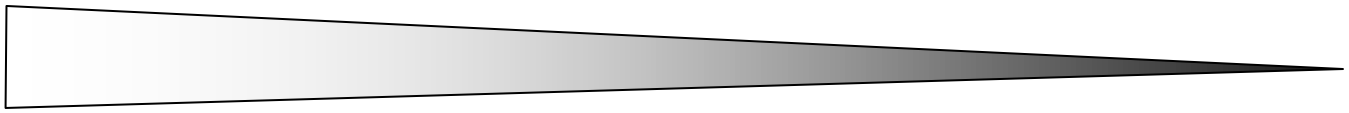
Volcanoes Rock Percent Silica and Texture Continuum



Rhyolite Pumice • Texture: porous • % Silica: + 69% • Viscosity: extreme Extrusive	*Dacite Pumice* • Texture: porous • % Silica: 62-68% • Viscosity: high Extrusive	*Andesite Pumice* • Texture: porous • % Silica: 55-61% • Viscosity: medium Extrusive	*Basalt Pumice* • Texture: porous • % Silica: 45-54% • Viscosity: low Extrusive
Rhyolite • Texture: fine grain • % Silica: + 69% • Viscosity: extreme Extrusive	*Dacite* • Texture: fine grain • % Silica: 62-68% • Viscosity: high Extrusive	*Andesite* • Texture: fine grain • % Silica: 55-61% • Viscosity: medium Extrusive	*Basalt* • Texture: fine grain • % Silica: 45-54% • Viscosity: low Extrusive
Porphyritic Rhyolite • Texture: two toned • % Silica: + 69% • Viscosity: extreme Extrusive/ Intrusive	*Porphyritic Dacite* • Texture: two toned • % Silica: 62-68% • Viscosity: high Extrusive/ Intrusive	*Porphyritic Andesite* • Texture: two toned • % Silica: 55-61% • Viscosity: medium Extrusive/ Intrusive	*Porphyritic Basalt* • Texture: two toned • % Silica: 45-54% • Viscosity: low Extrusive/ Intrusive
Granite • Texture: Coarse • % Silica: + 69% • Viscosity: extreme Intrusive	*Granodiorite* • Texture: Coarse • % Silica: 62-68% • Viscosity: high Intrusive	*Diorite* • Texture: Coarse • % Silica: 55-61% • Viscosity: medium Intrusive	*Gabbro* • Texture: Coarse • % Silica: 45-54% • Viscosity: low Intrusive



Gray Scale determined by % Silica

Ranger Program Box-O-Rox

Rock Number	*Case Evidence Letter*	*Rock Type*	*Distinguishing Characteristics*
1.	**A**	Porphyritic Dacite	Medium gray rock. Long, black hornblende crystals in a gray groundmass.
2.	**B**	Fine Andesite	Dark gray rock with crystals of similar size. Note small vesicles which may contain sediment. White minerals are feldspar, black are hornblende.
3.	**C**	Fine Dacite	Medium gray rock with crystals of similar size. Try to pick out the needles and blocks of black hornblende and the glassy, gray quartz. Feldspar is there, just very small.
4.	**D**	Rhyolite - Obsidian	Black glass with whitish coating from weathering.
5.	**E**	Dacite Pumice	Medium gray. Light-weight, some vesicles show glassy strands, tiny black needles are hornblende minerals.
6.	**F**	Basalt Pumice	Black color, light weight, many vesicles, may be oxidized and vesicles may contain dirt.
7.	**G**	Porphyritic Andesite	Medium sized white crystals (feldspar) in a dark gray groundmass. Some samples have vesicles, others do not and look more platey in handsample. A small amount of rust on some.
8.	**H**	Fine Rhyolite	Off-white rock with fine crystals. Also weathered and altered. Former vesicles have been filled in with white and discolored material. NOTE: spots and lines are not minerals, just secondary fill.
9.	**I**	Rhyolite Pumice	Tan-pink rock with many vesicles. Has been thoroughly weathered – would have been white.
10.	**J**	Andesite Pumice	Medium gray rock with some vesicles, lightweight.
11.	**K**	Granite	Mostly white rock. Large crystals of glassy-gray (quartz), blocky and pink (feldspar), rectangular and white with striations (feldspar), and oily black (biotite). May have rust spots or green weathering.
12.	**L**	Granodiorite	Medium-to-small crystals. Dark green minerals (hornblende) make up half the rock, weathered off-white minerals make up other half (quartz & feldspar).
13.	**M**	Diorite	Medium sized crystals with slightly more dark crystals than white (hornblende and feldspar).
14.	**N**	Gabbro	Large crystals with different shades of gray. Largest crystals are blocky and black (hornblende). White crystals are only small grains (quartz & feldspar).
15.	**O**	Porphyritic Basalt	Dark gray groundmass with distinguishable green crystals (pyroxene & olivine) and large feldspar crystals (rectangular and white). NOTE: This is very confusable with andesite, green minerals are the distinguishing mineral. Andesite will NOT have olivine.
16.	**P**	Fine Basalt	Black rock with flow marks and vesicles. Groundmass is so fine, that there are no crystals, glassy.
17.	**Q**	Porphyritic Rhyolite	Tan, off-white rock with small and large crystals. Large crystals are different colors. Rock is weathered.

Teacher's Instructional Sequence for 'Volcanoes Rock':

Pre-visit: The purpose of this activity is to give students an introduction to how geologists identify rocks. The activity at Johnston Ridge is best served when the students are prepared with the following information.

1) The purpose of the activity. (1) Students will learn how geologists identify rocks and why and (2) use their observation skills to conduct rock analyses. Different rocks have different characteristics. The characteristics of rocks produced at a certain locale, e.g. volcano, give us an idea not only of the volcano's history, but also of how it might erupt in the future. A volcano that produces **silica** rich rock, like dacite, has a strong likelihood of producing a explosive eruption. A volcano that produces low **silica** rock, like basalt, is less likely to erupt explosively. Large grained rocks indicate that magma cooled slowly underground, while fine-grained **texture** indicates that rocks cooled quickly on the surface.

2) The relevant vocabulary: **Igneous, Intrusive, Extrusive**, **Minerals, Silica, Texture, Vesicular, Viscous/Viscosity, Aphanitic, Phaneritic, Porphyritic, Matrix.** (See page 1).

3) The Case Facts: (see page 1)

4) Group Organization: Divide your class into groups of three to seven students. Each chaperone should expect to assist one group of students. Each group should be equipped with worksheet, clipboard, and pencil (sharpened).

Ranger Instructional Sequence for 'Volcanoes Rock':

Materials needed:
- Wheeled cart
- Rock samples
- Picture of basalt lava flow
- Diagram of core/mantle/crust
- Picture of plate tectonics/mantle plumes
- One copy of the texture/gray scale chart per group
- Rock identification table.

Optional materials
- Plastic honey bear
- Tube of toothpaste
- Bottle of soda

This activity can be conducted inside (near the blasted stump by the theatre exit, or outside on the plaza deck. After completing introduction, have students break into groups of 3 - 7. Have each group send one person to the front to get: (1) a rock/set of rocks, (2) a copy of the 'Volcanoes Rock' worksheet, (3) a pencil, (4) a clipboard on which to write, and (5) a laminated copy of the texture/gray scale chart.

Introduction (10 – 15 minutes)

Main Message – *The color and **texture** of a rock tell its story*

Background

1. Explain that the earth is comprised of three sections: the core, the mantle and the crust (*show diagram)* The Earth's mantle is fluid and hot → magma. Many **igneous** rocks form from magma that comes directly from the mantle (*show plate tectonics prop, indicate mantle plume)*. Other **igneous** rocks form due to plate tectonics. *(Explain that is what is happening here in the PNW. Show the subduction zone on the plate tectonics prop. Describe subduction, have students rub hands together for friction and heat).* Magma either cools and solidifies underground creating **intrusive** rocks, erupts on the surface as lava creating **extrusive** rocks.

2. We can tell what a volcano has done in the past, and get an idea of what it will do it the future by looking at the rocks produced. Rocks can be sorted by their percentage of **silica** composition and their **texture**.

Percent Silica Composition

Sub-message 1 – *The color of the rock can reveal the amount of **silica***

1. Explain that **silica** is a glass-like building block of **minerals**. Each **igneous** rock contains at least 45% **silica**. When a rock contains only a little **silica**, the **minerals** that form in it tend to be darker in color. What shade of gray would you expect a rock with little **silica** to be? BLACK (P*ick up a basalt rock and place near the rock cart.)* Basalt has the lowest percentage of **silica**, which ranges between 45-54 %, which is why it is so dark. Because the percentage is so low, its ability to resist flowing, or its **viscosity** is also low. Often when we think about volcanoes we imagine flowing red rivers of lava (*show picture of flowing basalt).* This flowing lava is basalt, which flows like honey.

2. Explain that on the far end of the **silica** scale there is a rock called Rhyolite. *(Pick Rhyolite sample and place it on the end of the rock cart on the opposite end from basalt—leave enough space between the two rocks to place two more rock samples between them.)* In order for a rock to be rhyolite, it must have more than (+) 70% **silica**. **Minerals** that form in the presence of so much **silica** tend to be lighter in color. With so much **silica**, what gray scale description could they make for rhyolite? LIGHT GRAY.

3. Between the two extremes on the platform are two intermediate rocks of different percentages of **silica** and therefore different shades of gray. *(Pick up both Dacite and Andesite.)* On the % **silica**, or gray scale chart, where would these two rocks fit? (Direct students to conclude that Andesite follows Basalt, and Dacite precede Rhyolite. Place Andesite and Dacite on the viewing platform). Explain to students that lava with more **silica** does not flow easily. If basalt flows like honey, then dacite with 62-68% **silica** flows like toothpaste *(pick up toothpaste)* or explodes violently like Mount St. Helens did on May 18, 1980.

4. Now that there are four samples on the rock cart, ask the students to compare them according to shades of gray. Direct students to identify *(pick up each rock as you announce it)* that Basalt is black, Andesite is dark-gray, Dacite is gray, and Rhyolite is light gray.

5. Explain that as in most cases, with rocks there is an exception to the rule. *(Pick up an example of obsidian)*. Ask students what they know about obsidian. (*Volcanic glass, Native Americans use(d) as tools).* Invite students to guess into which group this rock would belong. Explain, if students have not already figured this out, that obsidian is also called 'volcanic glass'. Because it contains so much **silica**, it actually belongs in the rhyolite group. The dark color comes from tiny **minerals** finely dispersed in the rock that are dark. There is little room in the rock for larger lighter colored crystals. Also, it cooled so quickly they didn't have time to grow.

6. All of the rocks that Mount St. Helens has erupted are basalt, andesite and dacite. Mount St. Helens has never erupted Rhyolite. (*Explain students can remember this because MSH produces B.A.D rocks).* Most of the rocks that have come out of Mount St. Helens in the last 2000 years are ones like this *(pick up dacite)*…gray. Dacite.

Texture

Sub-message 2 – *Rock **texture** tells us where and how quickly a rock formed*

1. *(Remove all rocks from the front of the rock cart except the dacite rock.)* Explain that each of the four rocks we just examined can take four **texture**s depending on how quickly they cool from lava to rock. Our remaining dacite and the next three samples will help us sort rocks according to **texture**.

2. Explain that there are primarily four **texture**s for **igneous** rocks. **Texture** refers to the size of crystals in the rocks. Magma contains many kinds of **minerals**, water, and gasses. *(Pick up soda bottle.)* When magma approaches the earth's surface *(begin shaking bottle)* gasses contained in the magma can begin to expand, because there is decreasing pressure on the magma. This produces foam *(point to soda foam)*. During an eruption both lava foam and lava rock are erupted out and cool quickly on the surface. These are extrusive rocks *(pick up dacite rock, sample and dacite Pumice and place them on the viewing platform)*. Direct students to compare the dacite rock and pumice. Except for **texture** all characteristics about these two rocks are the same. What is the major difference in **texture** between these two? The pumice has pores (small holes), and the rock does not. *(Place the dacite rock at the 'fine-grained' portion of the **texture** scale, and the dacite pumice at the porous portion.)*

3. (*Pick up the **porphyritic** Dacit sample and place it in the viewing area.)* Explain that **minerals** take different amounts of time, hundreds to thousands of years, to form in the ground. Because of the differences in time, some crystals will be long while others cannot be seen by the naked eye. These rocks are considered two-grained, and are called '**porphyritic**'. Since these rocks begin cooling in the ground they begin as intrusive rocks. However, these rocks finish cooling on the surface, so they are also extrusive. The resulting rocks will have both course (pre-formed) and fine (eruption formed) grained crystals.

4. Finally, the last rock in this scale *(pick up granodiorite sample)*. Explain that this rock cools completely in the ground, which allows **minerals** to grow large crystals to form a rock we call granodiorite. Where on our **texture** scale should this rock be placed? COARSE GRAINED. All the rocks in this series *(pick up each rock as you announce it)* dacite pumice, dacite, **porphyritic** dacite and granodiorite have the same **silica** content, viscosity and gray scale, but different **texture**s.

5. *NOTE: The rocks chosen for this activity have been selected to show trends and variations from rock to rock in order for students to see and feel the differences between them. In actuality, **igneous** rocks are often <u>not</u> limited to a singular **texture**. For example Pumice often is both **vesicular** (has pores) and **porphyritic** (contains both large and small crystals); some dacite rocks created during the 1980 eruption were fine-grained while others were two-grained (**porphyritic**).*

<u>Activity Directions</u>

- With these two scales, we can distinguish between 16 kinds of **igneous** rocks. Each group must successfully identify 8 rocks. *Groups are <u>not</u> allowed to share the identity of rocks with another group.* Each group is allowed one rock at a time, so one student will come up and get a rock and bring it back to the group. The group will describe the rock according to both **texture** and gray scale. After describing the rock, write down the sample number, the rock's name, **texture** and gray scale. When finished with the rock, one student may exchange it for another rock. While the students are working the ranger should circulate and answer any questions.

<u>Wrap-up</u>

- When the most groups appear to have finished eight samples, review the various rocks with the students and ask them to explain how they determined the rock types. Collect the clipboards, pencils and gray scale/**texture** charts. They can take the worksheet home with them.

BONUS - Bring out a breadcrust bomb. Have students describe what they see (color, **texture**s) and apply their new knowledge to explain what kind of rock it is.