Rock Cart for High School Students

Goals and Objectives for high school students (9^{th} – 12^{th} grade):

1) Define igneous rocks
2) Discuss chemical composition of rocks
3) Understand the plate tectonics and how it relates to volcanism (WA state 10^{th} grade science benchmark).
4) Identify rocks by silica content, minerals present and/or absent, and texture

Main Message: Igneous rocks can be identified by color and texture

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) Igneous rocks are comprised of many minerals including (from light to dark color) plagioclase, quartz, potassium feldspar, biotite, amphibole, pyroxene, olivine; the dominant mineral is silica.
4) Igneous rocks are differentiated by a percentage of silica
5) The amount of silica determines the shade of gray for each rock.
6) Lava with high silica content tends to flow more slowly (is more viscous) than lava with low silica content.
7) Igneous rocks with large crystals tend to have cooled slowly under the ground (intrusive)
8) Igneous rocks with smaller crystals tend to have cooled quickly above the ground (extrusive)
9) Rock samples.

Volcanic Vocabulary:

Texture: size, shape, and distribution of particles that make a rock
Silica: a glass-like building block of minerals
Intrusive: formation of rocks below the earth's surface
Extrusive: formation of rocks at the earth's surface
Viscosity: a fluid's ability to resist flow
Aphanitic: crystals to fine/small to be seen with the naked eye
Porphyritic: having distinct large crystals (as of feldspar) contained in a fine-grained matrix
Phaneritic: grains are all of similar (large) size
Vesicular: containing vesicles (i.e. pores in pumice)
Mafic: dark colored rocks, containing metals (e.g. iron, magnesium…) and low in silica
Felsic: light colored rocks, lacking large percentage of metals and high in silica
Feldspar: any of a group of crystalline minerals that consist of aluminum silicates with either potassium, sodium, calcium, or barium and that are an essential constituent of nearly all crystalline rocks
Olivine: Green in color, like an olive.
Hornblende: a mineral that is the common dark green to black variety of aluminous amphibole
Pyroxene: any of a group of igneous-rock-forming silicate minerals that contain calcium, sodium, magnesium, iron, or aluminum, usually occur in short prismatic crystals or massive form, are often laminated, and vary in color from white to dark green or black
Quartz: generally clear in color (may appear pink, gray or white), glassy, commonly found in granite, not present in basalt.

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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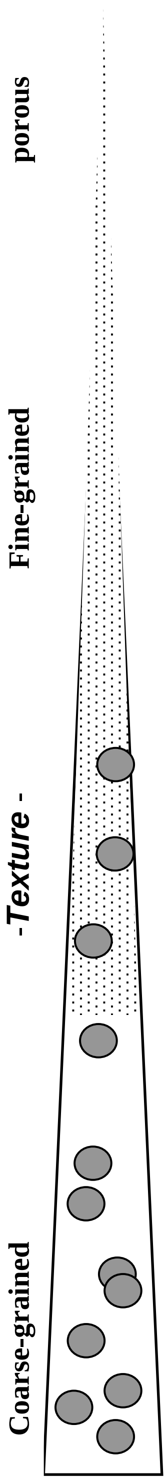
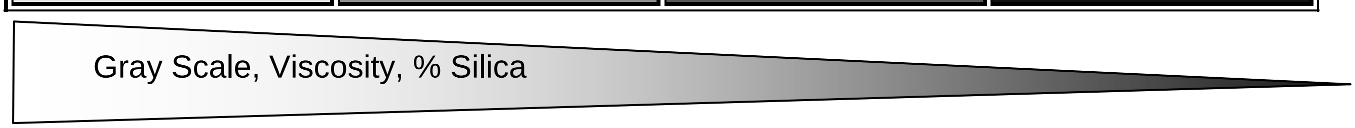
Volcanoes Rock Percent Silica and Texture Continuum



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



Master List for the 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. Samples from MSH.
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. Samples are from Ape Cave, MSH.
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. Samples from the MSH.
4.	D	Rhyolite - Obsidian	Black glass with whitish coating from weathering. This rock crystallized (cooled) so fast that there isn't a single grain in this sample. Samples are from Glass Mountain, CA.
5.	E	Dacite Pumice	Medium gray. Light-weight, some vesicles show glassy strands, tiny black needles are hornblende minerals. Samples from the Pumice Plain, MSH.
6.	F	Basalt Pumice	Black color, light weight, many vesicles, may be oxidized and vesicles may contain dirt. Samples are from MSH.
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. Samples are from Ape Cave, MSH.
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. Samples are from Death Valley, CA.
9.	I	Rhyolite Pumice	Tan-pink rock with many vesicles. Has been thoroughly weathered – would have been white. Samples are from…
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. Samples are from Mount Whitney, CA.
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). Samples are from the Feather River Canyon, CA, the Sierra Nevadas.
13.	M	Diorite	Medium sized crystals with slightly more dark crystals than white (hornblende and feldspar). Samples are from MSH.
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). Samples are from MSH.
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. Samples are from Beaver Bay area, MSH.
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 red and purple. Samples are from Death Valley, CA.

Instructional Sequence for ‘Volcanoes Rock’:

<u>Materials needed</u>:
- Wheeled cart
- Rock samples
- Picture of basalt lava flow
- One copy of the rock identification d chart per group
- Rock identification table.

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.

<u>Background</u>

1. Review that the earth is comprised of three sections: the core, the mantle and the crust (*show diagram/apple/egg/baseball?)*. The Earth’s mantle is fluid and hot → magma. Although we don’t completely understand the mechanism, it is believed that heat from convection in the mantle helps drive the crustal plates creating plate tectonics. Igneous rocks are a direct result of plate tectonics.
    a. Sea Floor spreading – new basalt rocks. Chemical composition like magma.
    b. Subduction zones. Superheated oceanic crust and continental crust mix, form magma, comes out from volcanoes. Discuss Juan de Fuca/North American plate boundary.

2. Igneous rocks come from hot magma, either from mantle or from melted rock at continental margins. Magma either cools and solidifies underground creating intrusive rocks, or when it erupts on the surface as lava creating extrusive rocks.

3. The cooled rocks can be sorted by their percentage of silica composition and their texture.

<u>Composition</u>

4. 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. Will never find quartz in basalt, will never find olivine anywhere but basalt (*do we have examples of these minerals?)* 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.

5. 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.

6. 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**.) O*n 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*.*

7. 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 <u>black</u>, Andesite is <u>dark-gray</u>, Dacite is <u>gray</u>, and Rhyolite is <u>light gray</u>.

8. Explain that you there are always exceptions to the rules. *(Pick up an example of **Obsidian**)*. Ask students what they know about obsidian. 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; these minerals are magnetite (Fe_30_4) and 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.

9. All of the rocks that Mount St. Helens has erupted are Basalt, Andesite and Dacite. Mount St. Helens has never erupted Rhyolite. 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.

<u>Texture</u>

10. *(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 textures 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.

11. Explain that there are primarily four textures 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.)*

12. (*Pick up the porphyritic Dacite 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.

13. 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 textures.

14. *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).*

15. 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.

Wrap-up

16. 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.

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