Lunar Geology

Background

Geologists are scientists who study the formation, structure, history, and processes (internal and on the surface) that change Earth and other planetary bodies. Rocks and the minerals that they are composed of give geologists key information about the events in a planet's history. By collecting, classifying, and analyzing rocks, we can learn how they were formed and what processes have changed them.

Geologists classify rocks into three general types:

- **Igneous -** rock formed when magma cools and hardens either below the surface (a common example of this is granite), or on the surface during volcanic events (for example, basalt).
- **Sedimentary -** rock formed by the collection, compaction, and cementation of eroded mineral grains, rock fragments, and sand (for example, sandstone and shale).
- **Metamorphic -** rock formed when heat and/or pressure deep within the planet changes the mineral composition and grain size of existing rocks (for example, metamorphism changes limestone into marble).

Geologists can further identify rocks by determining their mineral composition. Depending on the amounts and types of minerals found in a rock sample, a rock may be classified in a number of different categories. The mineral composition can also give scientists clues as to where and how the rock was formed.

The Moon's surface is dominated by igneous rocks. The lunar highlands are formed of anorthosite, a light-colored igneous rock with visible grains. It is by far the most common type of rock on the surface of the Moon. The lunar maria are made of layers of basaltic lava, not unlike the basaltic flows of the Columbia River Plateau in the northwest part of the United States. Breccias, which are made of rock and mineral fragments that have been fused together by the heat of meteoroid impacts, are also common on the surface.

Topic

Lunar Geology

Objectives

Students will:

- Investigate and identify mineral content in simulated lunar rocks.
- Investigate and identify simulated lunar rocks based on mineral content.

Overview

Students will cut cross sections of simulated lunar samples to determine the mineral content. Using this information students will identify different types of lunar rocks.

Key Question

How do geologists identify lunar rock samples?

Key Concept

- Rocks can be identified by the percentage of minerals that make up each sample.

Preparation & Materials

- Two packages of clay
- Sewing beads:

  white, (longer than wide) for plagioclase

  brown, (almost square) for pyroxene

  green, (almost round) for olivine

  black, (almost square) for ilmenite (optional for activity extension)
- Nine small air tight containers
- Floss, thin wire, plastic knives, or any other apparatus for slicing clay samples
- Masking tape

1. To make an anorthosite sample, count out 360 white beads, 20 brown beads and 20 green beads. Knead these beads into a ball of clay. Divide this thoroughly mixed clay into thirds. Place these mock lunar samples into an air tight container. Using the masking tape and a marker, label the container with a number. Record the

number and note on a piece of paper that this number represents anorthosite.

2. To make a norite sample, count out 240 white beads, 140 brown beads and 20 green beads. Knead these beads into a ball of clay. Divide this thoroughly mixed clay into thirds. Place these mock lunar samples into an air tight container. Again, label the container with a number and, for future reference, record the number and rock type.
3. To make a troctolite sample, count out 240 white beads, 20 brown beads and 140 green beads. Knead these beads into a ball of clay. Divide this thoroughly mixed clay into thirds. Place these mock lunar samples into an air tight container. Again, label the container and record the rock type on your answer key.
4. Scientists use a thin slice method to identify a rock. The crystals on the surface of the slice are classified and then the amount of each mineral is determined. A rock is then identified by the percent of each crystal found in the sample. Have each student take one of the mock lunar samples and record the letter of the rock sample on a separate piece of paper. This paper will be their data sheet.
5. Have the students gently slice the sample in half. Using the information given in the Lunar Geology Student Worksheet, have students determine the mineral crystal that is represented by each of the beads. Have them count the number of each type of crystal (beads) and record that number on the data sheet. Each side of the split mock lunar sample is considered a thin slice.
6. The students should repeat step 5 two times, kneading the clay together in between slices.
7. Have the students calculate the average amounts of beads in each sample. Have them record their calculations and answers.
8. Use the averages to have the students calculate the percentages of beads in each sample. Again, record the answers.
9. Repeat steps 4-7 for the remaining two samples.
10. Using the percentages given in the student fact sheet, have the students identify the types of rocks provided. You may check their answers with the answer key you created.
11. Have the students complete the Question and Conclusion portion of the worksheet.

Management

- Divide students into cooperative groups
- Three 50-minute class periods
- Make the clay samples before the activity is to be performed.
- When purchasing beads, avoid those which are covered with a thin layer of paint (such as a metallic or opalescent bead). The paint tends to shed when it is in the clay, and makes it difficult to differentiate between the paint and the actual beads.
- Review how to calculate percentages and averages before beginning this activity.

Reflection & Discussion

1. Could we have done this sort of rock identification to Moon rocks before the Apollo missions? Why or why not?
2. Did you always count the same percentage of minerals in every slice you took of a given sample? Did you ever get the exact percentage that was given in the student worksheets? Is science always exact?

Transfer/Extension

1. With the remaining clay, beads, and the optional black beads, make up samples of the mare basalts. (To make a high-titanium sample, use 72 black beads, 12 green beads, 216 brown beads, and 120 white beads.) Using the data table, have the students try to classify this new rock.
2. Arrange to go to a local college or university with a geology department. Ask to see examples of the equipment used to identify rock types, and also to look at rocks that resemble those found on the Moon.

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Student Procedures

1. Scientists use a thin slice method to identify a rock. The crystals on the surface of the slice are classified and then the amount of each mineral is determined. A rock is then identified by the percent of each crystal found in the sample. Take one of the mock lunar samples and record the letter of the rock sample on a separate piece of paper. This paper will be your data sheet.
2. Gently slice the sample in half. Using the following table, determine the mineral crystal that is represented by each of the beads:

MINERAL	ELEMENTS	APPEARANCE IN MOON ROCKS
Plagioclase feldspar	calcium (Ca), aluminum, silicon (Si), oxygen (O)	Off-white to translucent grayish; usually occurs as grains longer than they are wide.
Pyroxene	iron (Fe), magnesium, (Mg), calcium (Ca), silicon (Si), oxygen (O)	Brown to black; grains usually longer than wide in mare basalts, almost square in highland rocks.
Olivine	iron (Fe), magnesium (Mg), silicon (Si), oxygen (O)	Greenish; usually occurs as almost round crystals.
Ilmenite	iron (Fe), titanium (Ti), oxygen (O)	Black, elongated to almost square crystals.

Count the number of each type of crystal (beads) and record that number on the data sheet. Each side of the split mock lunar sample is considered a thin slice.

3. Repeat step 2 two times, kneading the clay together in between slices.
4. Calculate the average amounts of beads in each sample. Record your calculations and answers clearly on the worksheet.
5. Use the averages you found to calculate the percentages of beads in each sample. Again, record the answers.
6. Repeat steps 1-5 for the remaining two samples.
7. Using the following percentages, identify the types of rocks provided.

Mineral abundance (percent) in Moon rocks

	Plagioclase	Pyroxene	Olivine	Ilmenite
Highland rocks				
Anorthosite	90%	5%	5%	0%
Norite	60%	35%	5%	0%
Troctolite	60%	5%	35%	0%
Mare basalts (transfer/extension project)				
High-titanium	30%	54%	3%	18%
Low-titanium	30%	60%	5%	5%
Very low-titanium	35%	55%	8%	2%

8. Complete the Questions and Conclusions portion of the worksheet, writing down your answers on your data sheet.

Questions & Conclusions

1. This process represents one way to classify rocks. Can you think of any other ways scientists might use to try to classify rocks? What are the advantages or disadvantages of each? Is there a disadvantage to this method?
2. Why do you think that you took the average of several rock slices? Do you think it would have been better to take more, or just as effective if you took less? Why?

Date Taken: 02/06/71
Title: View of large boulder found by Apollo 14 crew

This is one of the white rocks from which samples were taken by the astronauts of the Apollo 14 lunar landing mission.

Image courtesy of NASA