

Module 4: Finding Treasures of the Moon

In this module, students will continue their exploration of the properties of the Moon and will create their own hypotheses on the Moon's geological history and the role that the Moon Mineralogy Mapper will play in testing scientists' current understanding of the Moon's composition and geologic history.

Activity 4-1: Lunar Treasure Hunt (40 minutes)

Teams compare their maps to topographic maps of the Moon. Students use their spectroscopic data from the Moon and understanding of cratering to create questions and devise some theories for the geologic history of the Moon.

Activity 4-1: Lunar Treasure Hunt

Overview

In this 40-minute activity, teams of students create and compare color-coded mineralogy maps and topographical maps of the Moon. Using spectroscopic data and their understanding of cratering and volcanism from previous Module 3 activities, students create questions and devise theories for the geologic history of the Moon.

Learning Objectives

- Contrast mineralogy maps and topographical maps of the Moon to describe lunar features in terms of their rock types.
- Evaluate the value of spectroscopic data.
- Create and examine hypotheses explaining the geologic history of the Moon.

Key Concepts

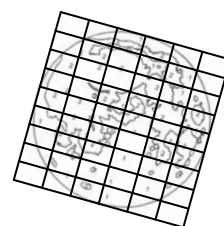
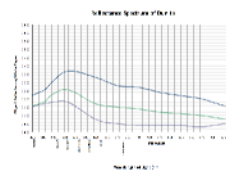
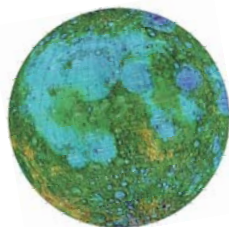
- The Moon has small craters that reflect light well at some wavelengths (visible and mid-infrared) so they appear bright.
- The Moon has large round basins that reflect light poorly at many wavelengths (from ultraviolet through infrared) so they appear dark.
- Craters provide clues to the composition and internal structure of the Moon.
- Our understanding of the Moon is based on the Apollo rock samples and meteorites from the Moon, and our spectroscopic and visual observations of the Moon.
- More detailed data are needed to test our current models of the Moon's rock types, geologic history, and structure.
- Scientific investigation includes observations, gathering, analyzing, and interpreting data, and using technology to gather data.

Materials

For each team of 4-5 students:

- Spectral graphs from the Activity 2-2: Moon Mineralogy Expedition—Rock Type #1, Rock Type #2, and Rock Type #3 (anorthosite, basalt, and dunite (olivine))
- One color copy of the Lunar Topographic Map
- One copy of Color Coded Moon Map with regions characterized by numbers

- Colored markers, pencils, or crayons: yellow, grey, and green
- A copy of each of the Activity 2-2: Rock Information sheets



Preparation

- Print out color copies of the Lunar Topographic Map for groups of 4-6 students, or print out posters for the entire class to observe, or prepare to project the image for everyone to see.

Addressing Prior Knowledge

- Begin by asking the class to describe their previous activities related to the Moon, particularly the Moon Mineralogy Expedition, their examination of missions gathering data from the Moon, and the geology activities on cratering and lava layering.
- **What types of rocks have scientists found on the Moon?**
[anorthosite, basalt, dunite (olivine-rich), and more]
- **Why do we think those are the rocks on the Moon?**
[We have samples of these rocks gathered by the Apollo astronauts from a few specific locations on the Moon, and we have spectroscopic data for larger areas on the Moon.]
- **Could there be other types of rocks on the Moon? How complete is our knowledge?**
[There could be other types of rocks; our data is patchy and low-resolution.]
- **What do we need to have a more thorough understanding of the Moon?**
[We need a more detailed data for the entire surface of the Moon.]

The Activity

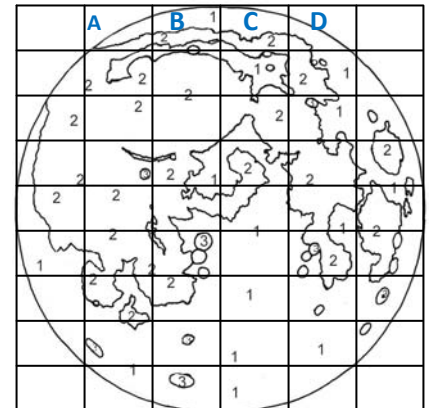
1. Divide your class into groups of 4-6 students and distribute materials to each group (a copy of the Color-Coded Map of the Moon, along with either crayons, pencils, or markers).
2. Tell students that they will use the graphs of the various rocks from their Moon Mineral Expedition to create a map of the composition of the Moon's surface—a mineralogical map of the Moon. Model the process with the students. The numbers on the map indicate where spectra have been taken, matching the rock types the "Orbiters" collected. For instance, wherever a "2" is shown, a spectrum was collected from rock type 2. Using their information from Remote Analysis of the Moon, students should identify the rock types and color in the map.
 - **Is there any pattern to the distribution of rock types? Which cover the greatest area? The least?**
3. After they are finished color-coding their maps, review what they know about the rocks and how they form from Modules 2 and 3. The students may need to revisit the Rock Information Sheet. Ask them to reflect on where the different rock types occur on their mineralogical map of the Moon.
 - **How do basalts form?**
[Basalts are volcanic rocks that form from molten lava.]
 - **What does the presence of basalt on the Moon tell them?**
[That the Moon was or is volcanically active.]
 - **Do they see any patterns to where the basalts occur on their map?**
 - **What other ideas or questions do your students have so far, based on this information?**

4. Hand out a copy of the Lunar Topographic Map to each team. Students should identify key features from the Lunar Topography map.
 - **Which parts of the Moon are the highest (the highlands)? Which parts of the Moon are the lowest?**
 - **How would the students describe the lowlands?** [Smooth, dark.]
 - **How would the students describe the highlands?** [Light, rough.]
 - **What makes the highlands rough? What are the circular depressions called? How do they form?** [Remind the students that they experimented with forming craters in the activity.]
 - **Which of the craters are the deepest?**
 - **What are some of the properties of the basins?** [Basins are broad, flat, low features.]
 - **Are some of the basins higher than others?**
 - **Which of the basins have the most craters in them? Which of them have the fewest craters? What does that tell us about the ages of the basins?**
[The basins with more craters are older; the basins with fewer craters are younger.]
5. Teams compare their mineralogy maps to topographical maps of the Moon, and classify the rocks in the craters, in the basins, and in the highlands.
 - **What types of rock is found in the basins?**
[basalt]
 - **Are these basins different from each other?**
 - **What types of rocks are sometimes found inside the craters?**
[anorthosites, dunite (olivine), and others]
 - **Are these craters different from each other?**
 - **What types of rocks are found in the lunar highlands?**
[mostly anorthosite]
 - **Are these regions different from each other?**
6. Ask your students to think about the Moon, its topography, the types of rocks found in different locations on the Moon, and where those rocks are found on Earth.
 - **Which parts of the Moon are the oldest? Why do they think so?**
[the highlands are the oldest; they have the most craters]
 - **What types of rocks are found in the oldest parts of the Moon?** [anorthosite]
 - **Which parts of the Moon are the youngest? Why do they think so?**
[The flat basalt-filled basins are the youngest; they have the fewest craters.]
 - **Where are those rocks found on Earth? How do you think they formed there on the surface of the Moon?** [Scientists believe that cracks in the Moon's crust allowed hot lava from inside to flow out onto the Moon's surface.]
 - **Which parts of the Moon's surface are the deepest?**
[craters]
 - **What types of rocks are found there?**
[anorthosites, dunite (olivine), and others]
 - **Where are those rocks found on Earth?**
[dunite is found in our mantle]

- **How do you think they got to the surface of the Moon?** [Impacts uncovered the layers above these rocks, exposing rocks that may have intruded into the crust of the Moon.]
7. Invite the students to reflect on the activity and analyze their understanding of our exploration of the Moon.
- **What do the students think the point of this activity was?**
[Answers could include analyzing data, creating hypotheses, understanding the scientific process, and understanding the formation and evolution of the Moon.]
 - **Which aspects of science did your students do today?**
[Answers could include analyzing or comparing data, creating hypotheses and making predictions, sharing conclusions.]
 - **What do your students believe is the value of understanding what our Moon is made of?**
[Knowing about resources for future manned exploration of the Moon; compositional information can be used to improve our current models of the Moon's formation and its geologic evolution.]
 - **What do your students believe is the value of understanding the Moon's formation or evolution or structure?**
[Scientists can apply what has happened to our Moon to better understand our own Earth and the broader history of the Solar System.]

Extension

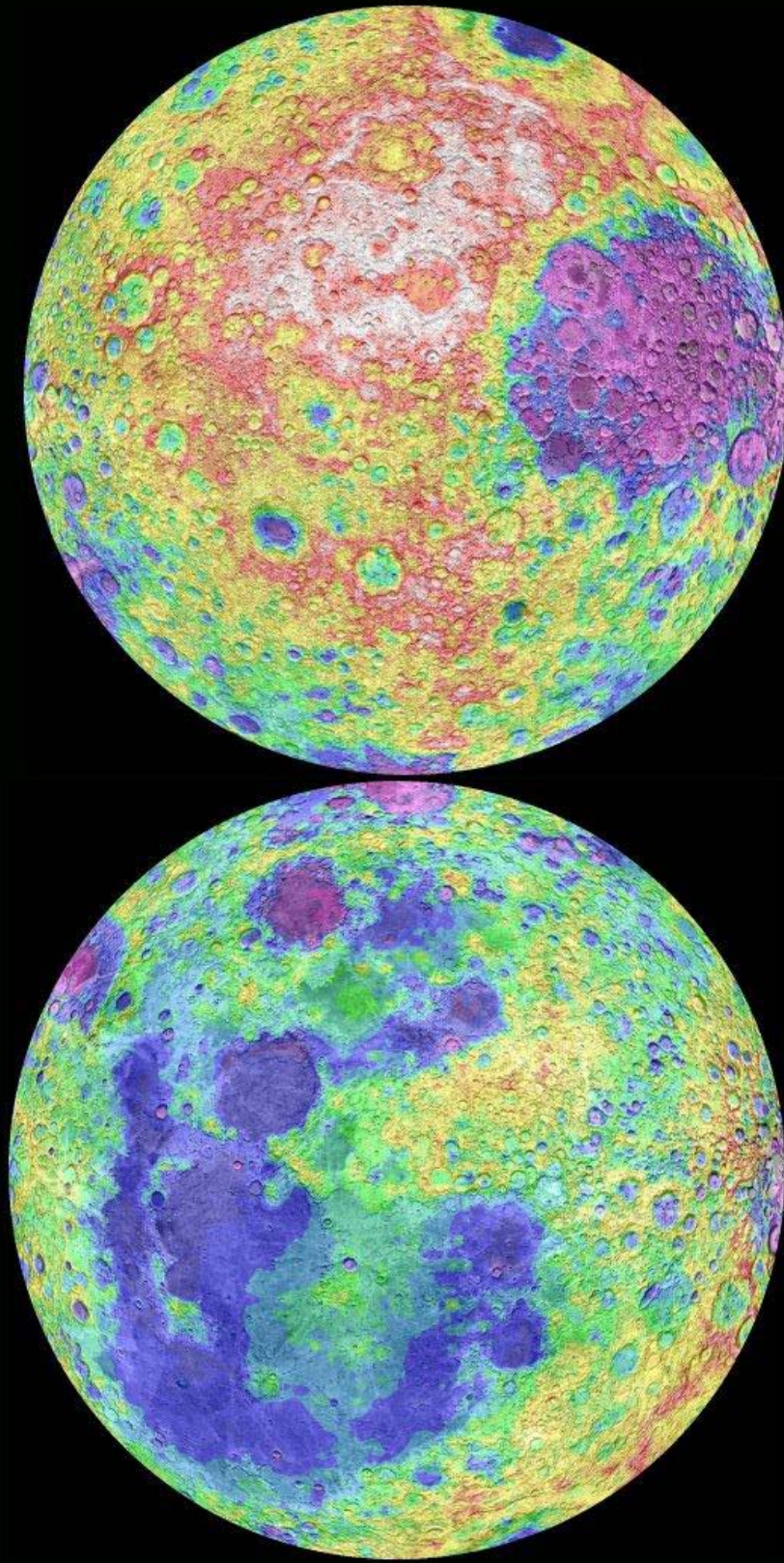
To integrate mathematics into this lesson, consider having students estimate the relative abundance of the rock types per square area in the grid. Each square covering the Moon should be given a unique identifier (e.g., labeled A, B, C...XX, as there are 50 squares covering the Moon's surface). Relative abundance can be calculated by $\text{Total abundance of Rock Type} / \text{Total Abundance of All Rock Types}$. Students could also analyze the data to build frequency table and histograms, or perform central tendency calculations. Students may collect data into a data table like the one below:



Square ID	Amount of Rock per Square			Total
	Anorthosite	Basalt	Dunite/Olivine	
A	.55	.45	0	1
B				
C				
D...XX				
Estimated Total				

Clementine Topographic Map of the Moon

Contour Interval - 500 m



Near Side

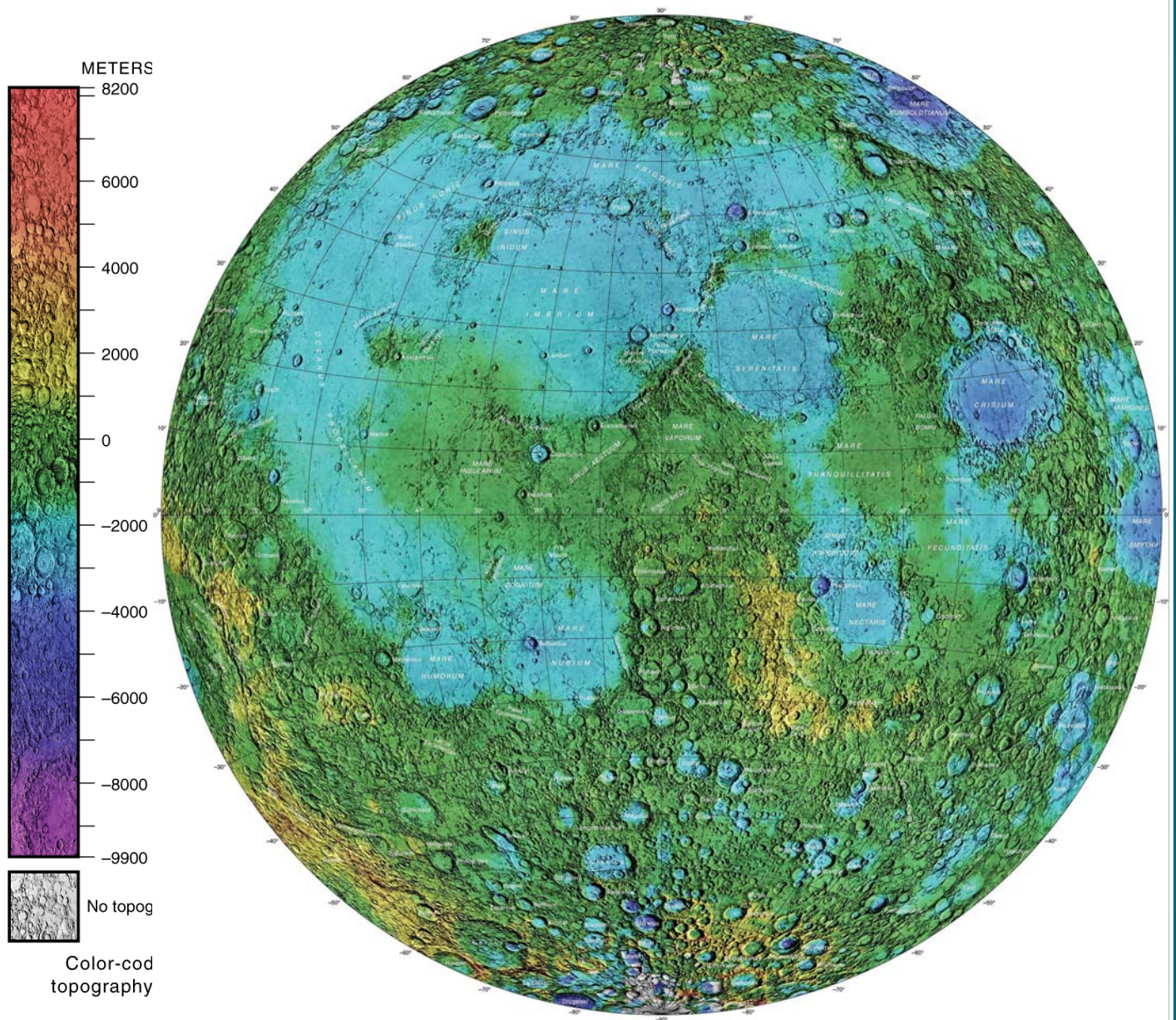
Far Side

Kilometers

Color-Coded Topography and Shaded Relief Map of the Lunar Near Side and Far Side Hemispheres

By U.S. Geological Survey

2003



Color-Coded Moon Map

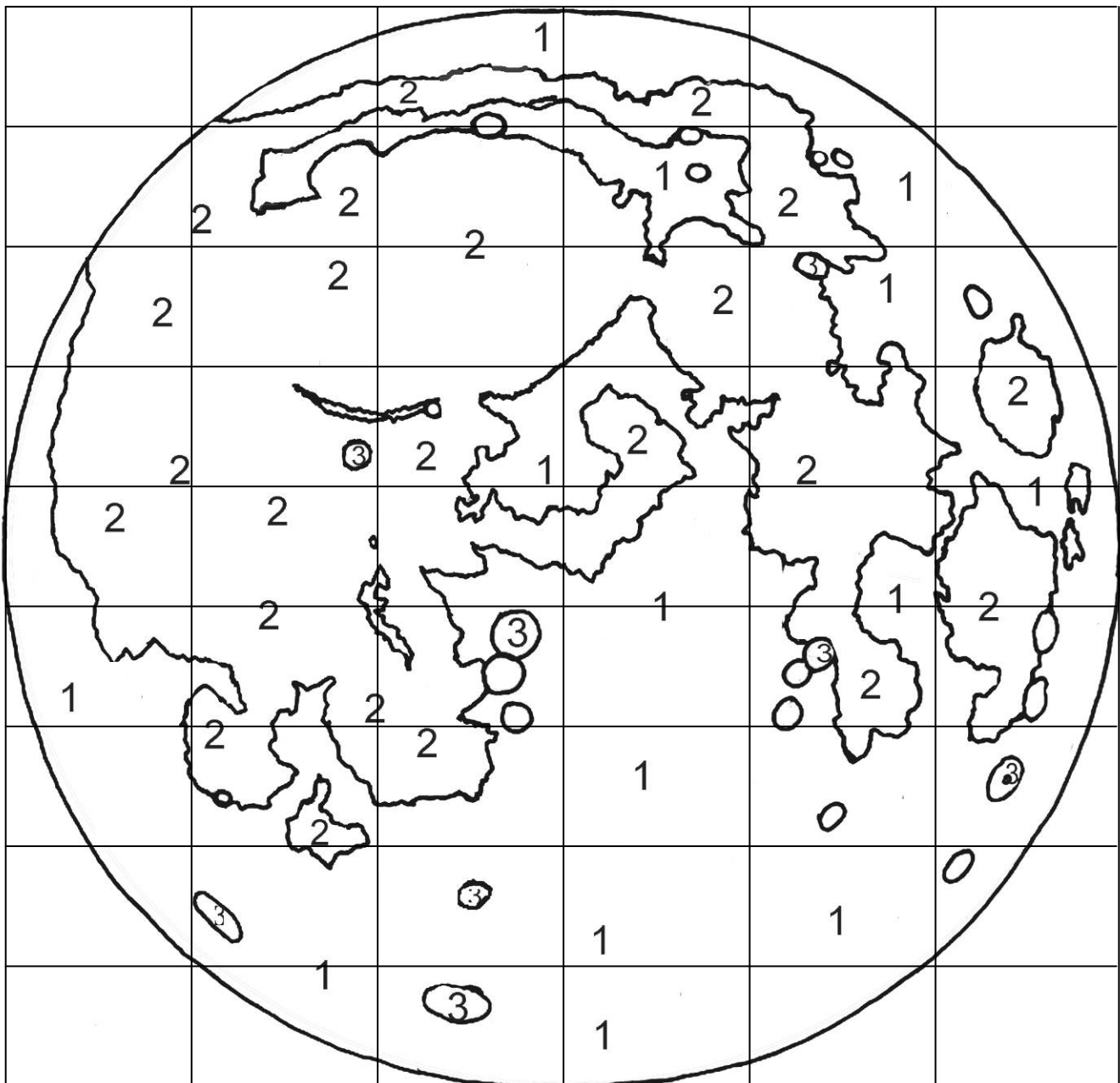
EDUCATOR

Directions

Color the areas with the anorthosite spectrum yellow, color the regions matching the basalt spectrum dark grey, and color the portions matching the olivine spectrum green.

Code:

- 1 is anorthosite
- 2 is basalt
- 3 is olivine



Color-Coded Moon Map

STUDENT

Directions

Color the areas with the anorthosite spectrum yellow, color the regions matching the basalt spectrum dark grey, and color the portions matching the olivine spectrum green.

Code:

1 is _____ 2 is _____

3 is _____

