Lesson 5: Why Matter and Minerals Matter!

Summary

This learning module and related laboratory exercise exposes students to the make-up of minerals and rocks on both Earth and Mars.

Learning Goals

Students will be able to:

- Observe different rock-forming minerals and explain their relationship with water.
- Use CRISM and HiRISE images to identify regions on Mars where aqueous conditions might have been present.

Context for Use

This learning module is meant for adaptation in an introductory earth science course and/or planetary science course. Provide students with an introduction to the atom and the periodic table to provide context and a resource to understand mineral formation.

Description and Teaching Materials

In-Class Activity

In-Class Activity 1: Follow the water with minerals

Homework/Lab

Homework 1: Identifying the clay: Endeavor Crater

Teaching Notes and Tips

1. For *In-Class Activity 1* either (a) print off colored copies for students (b) have hand sample specimens of each mineral for students to observe or (c) use the image file to show students the minerals.
2. For a large class size >20 where you would like to use hand-specimens, have a scope attached to your projector so students may observe "up-close".
3. Become familiar with JMARS software prior to class (loaded on whatever machine you will be using for presentation), especially with viewing CRISM and HiRISE image stamps to discern mineralogy on Mars.
4. Students should have a working understanding of how to navigate and use JMARS prior to completing *Homework 1*.

Assessment

Assessment is imbedded within each *In-Class Activity*.

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References and Resources

1. Image File: Matter and Minerals
2. CRISM webpage: http://crism-map.jhuapl.edu
3. HiRISE webpage: http://hirise.lpl.arizona.edu

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In-Class Activity 1
Building Blocks: Matter and Minerals_MFE
Follow the Water with Minerals

Purpose
Observe various minerals and identify their connection to water using their chemical formulas and environments of formation.

Preparation
1. Assemble mineral hand samples of: hematite, calcite, gypsum, olivine, feldspar, and kaolinite (or other smectite)
2. If hand samples are not available use the mineral images provided in the module *Image File*

Engage
Show images and/or hand samples of a few of the minerals listed in *Preparation*. Ask students to quickly make a hypothesis as to which minerals indicate aqueous environments.

Explore
- Ask students to indicate whether or not each mineral has an aqueous history of formation/precipitation.
- Once students determine the aqueous history have them connect the mineral to its most probable environment of formation.
- Ask students if they think that these minerals could have multiple environments of formation and why.

Explain
1. As students work to identify, with sound reasoning, which minerals indicate an aqueous environment of formation describe the minerals in terms of their properties and general classification (i.e. sulfates, hardness, cleavage etc.).
2. Provide students a context of the environments of formation (shield volcano, desert playa, hot springs, pluton, altered volcanic tuff, coastal shelf) listed for students to connect each mineral to its most probable environment of formation. Should you desire, you could provide a PowerPoint slideshow of the environments.
3. Encourage students to list their reasoning for their answers.

Elaborate
- Rank the minerals according to what students believe to be their relative abundance on Mars. Highest = most abundant on Mars, Lowest = least abundant on Mars
- Discuss with students their ranking system and their method behind the ranking.
- Share with students a Mars geologic map to give them an idea of the rock types across Mars (see link: http://www.lpi.usra.edu/resources/mars_maps/1083/).

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Evaluate

1. Evaluate student response as they interpret the images.
2. Can students recognize, from the chemical formulas of minerals, which minerals could indicate an aqueous environment? Observe this by their ranking and method of ranking in **Elaborate** and throughout the **Explore** sections.

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Homework 1
Matter and Minerals_MFE
Identifying the Clay: Endeavor Crater

Objective: To further utilize the tools offered within the software JMARS and investigate mineralogies observed at Endeavor Crater.

Introduction: In order to accomplish this lab the students will need to register and download JMARS. By this point, they should be familiar with JMARS software and how to navigate to regions of interest on Mars.

1. Using the Nomenclature Layer, navigate to Endeavor Crater (approx. 354.7705°E, -2.2480°N).
    a. For best viewing results, Zoom to 1024 and center the main screen on the western rim of Endeavor Crater
    b. If the students still have their nomenclature layer turned on, they will see the labeled "Endeavor" to the right of the rim they are exploring

2. Choosing HiRISE stamps to explore Endeavor Crater with the highest resolution possible.
    a. Using the stamps layer choose either HiRISE DTMS or HiRISE full stamps. Make sure the students zoom in close so that when they search for HiRISE stamps hundreds do not try to load. Use the "main view" to limit the search of HiRISE stamps. Choose stamps rendered by ASU.
    b. Compare and contrast the HiRISE DTM images and the HiRISE Full stamps images. Which do the students prefer and why?

    c. Consult the webpage: http://hirise.lpl.arizona.edu/dtm/about.php . After consulting the webpage, which set of imagery would they rather use, DTM or Full stamps? Did their choice change? Why or why not?

    d. Decide which HiRISE imagery the students will choose to display and explore the western crater rim.

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3. Exploring the mineralogy of Endeavor Crater using CRISM
    a. Add the CRISM stamps layer and use a different outline color to differentiate CRISM and HiRISE stamps. To display CRISM stamps, use the "Main View" to set the bounds of the image search.
    b. Provide a rough estimate of the number of CRISM stamps: _____
    Do they outnumber the HiRISE DTM stamps or full stamps? Why do the students think this is (think of current/past mission objectives)?

    c. Start exploring some of the CRISM stamps intersecting the HiRISE DTM stamps. Choose any stamp and the ASU-rendered images. When using ASU images, use the *color overlay*. ASU provides the students with a number of options. List at least three below (i.e. Ferric Mineralogy):

    d. Find a CRISM stamp that is rendered for phyllosilicates. Where are the phyllosilicates located in the crater (the rim, the rim wall, or the bottom of the crater)? What does this tell them? *Note: the warmer the color the higher content of the respective mineral.

    e. Compare the sulfate CRISM overlays. Are sulfates found in the same region as the phyllosilicates? Why or why not?

    f. Select another crater on Mars that has CRISM stamps available. Compare and contrast the phyllosilicates abundance between the two craters below. Please name the crater and its coordinates for verification.