Lesson 7: Life Hosting Rocks

Summary
This learning module and related laboratory exercise exposes students to the types of lithologies on Earth that host life and the sedimentary processes that formed them.

Learning Goals

Students will be able to:

- Recognize and identify sedimentary rocks on Earth and Mars.
- Identify sedimentary structures that provide clues as to the environment of formation (i.e. mud cracks, cross-bedding etc.).
- Observe the expansion of clays and explain why water influences clay-rich rocks at the molecular level.

Context for Use
This learning module is meant for adaptation in an introductory earth science course and/or planetary science course. Students need a prior knowledge of minerals before going through this module. Provide an understanding of grain sorting and sedimentary structures resulting from varying energy in the system (i.e. low energy = laminations; cross-bedding = higher energy system).

Description and Teaching Materials

In-Class Activity

In-Class Activity 1: Swelling Rocks

In-Class Activity 2: *Understanding Albedo*

Homework/Lab

Homework 1: The Energy of Rocks

Teaching Notes and Tips

1. The *In-Class Activities* can be utilized as homework as well. The activity is designed as such that students can effectively complete the activity at home.

Assessment

- Each *In-Class Activity* and *Homework* has its own method of assessment.

THE UNIVERSITY OF UTAH®

Sponsored by:
National Aeronautics
and Space Administration
NASA Award (NNX11AH29G)

Mars for Earthlings

References and Resources

1. Image file: Life-Hosting Rocks
2. Swelling clay-rich soil demonstration: http://www.youtube.com/watch?v=ACpuYED9WkU
3. Ripple-formation video: http://www.youtube.com/watch?v=zRGuMddjRGg&list=PL17AFB4B8AB3DCCF7
4. Laminar-flow video: http://www.youtube.com/watch?v=W3YZ5veN_Bg

Mars for Earthlings

In-Class Activity 1
Life-Hosting Rocks_MFE
Swelling Rocks

Purpose: Explain why clay soils expand and discern where clays might be present on Mars.

Engage
Expanding Soil - Observe the class demonstration or video [http://www.youtube.com/watch?v=ACpuYED9WkU] and answer the following questions.

1. According to the demo/video, why does the soil expand?

2. How does the bulk density change? What does this change indicate?

Explore
The molecular level- Utilize the diagram below to help students understand how clays are made up of stacked layers. (Figure 1) Students should answer the following questions.

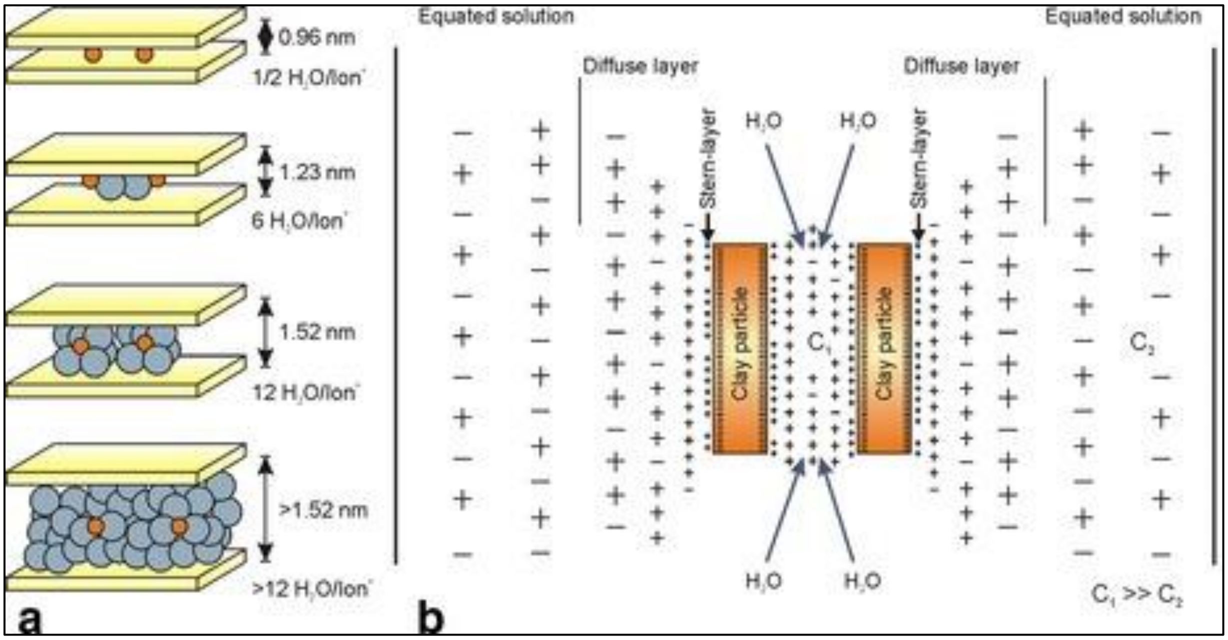

Figure 1: Butt et al., 2003

1. In Fig. 1a, how are the water molecules influencing the structure?

2. Why do the students think the water attracts to the clay rather than the sand of the sandy loam (consult Fig. 1b)?

Mars for Earthlings

Explain

Share the following information about clays with students:

- Clays are expandable due to their layer charge. The higher the layer charge (for example montmorillonite or bentonite) the more the clay will expand.
- The interlayer (the charged layer) attracts water molecules allowing for the clay to expand
- Clays are commonly formed in pedogenic, hydrothermal, or acid lake environments on Earth.

Elaborate

3. Given the students understanding of clays now, if clays [$Na_{0.2}Ca_{0.1}Al_2Si_4O_{10}(OH)_2(H_2O)_{10}$] are observed on Mars….what does this mean?

Evaluate

4. Where might students look to find clays on Mars (what kind of features)? *Hint: consider their environment of formation, do we have evidence for their presence on Mars?

Mars for Earthlings

In-Class Activity 2
Life Hosting Rocks_MFE
Understanding Albedo

Purpose: Recognize sedimentary rocks on both Earth and Mars using the albedo effect.

Resources:
1. Last Chance Canyon, Guadalupe Mountains, NM image in Image file: Life-Hosting Rocks
2. Interactive Earth Surface Albedo Map (NASA-CERES): http://www-surf.larc.nasa.gov/surf/pages/bbalb.html
3. Earth surface types map (NASA-CERES): http://www-surf.larc.nasa.gov/surf/pages/sce_type.html
4. Global albedo map of Mars: http://www.mars.asu.edu/data/tes_albedo/large/tes_albedo_label.png
5. Global albedo map of Earth: http://eoimages.gsfc.nasa.gov/images/imagerecords/60000/60636/modis_albedo.jpg

Engage
Present the following along with an image of Last Chance Canyon, New Mexico (see Image file: Life-Hosting Rocks):

Scenario: The students are planning to hike Last Chance Canyon in the Guadalupe Mountains National Park. It is arid, no winds, and about 95°F. If they had the following options for attire which would they choose and why:
- Sleeveless cotton medium blue colored shirt
- White long-sleeve cotton shirt
- Black long-sleeve cotton shirt

Discuss student response and their reasoning.

Explore
1. Use the interactive Earth Surface Albedo Map and Earth surface types map (produced by NASA-CERES in **Resources**) and ask students which surface types correspond to the highest albedo.
2. Probe students as to why some “surfaces” have a higher albedo than others (i.e. ice, ocean, desert, forest cover, grassland, etc.)
3. Display hand samples of sandstone, andesite, and basalt (or use the Image file: Life-Hosting Rocks). Ask students to rank the samples according to their albedo effect.

4. If students were to picture an albedo map of Mars, do they think the surface would be as variable as Earth? How do the students think that, overall, the albedo of Mars would compare to that of Earth?
5. After the students have discussed these questions, compare the global albedo maps of Earth and Mars (in **Resources** above).

Explain

Explain the terms 'reflectance' and 'albedo' using the definitions below. Relate them to the discussion in the **Engage** section.

- Reflectance- Reflectance is a surface's ability to reflect light and is a property of the material.
- Albedo- Albedo is the measure of the percentage of solar energy reflected by a surface, typically that of a planet or moon. It is expressed as the ratio of light reflected by a surface to the total incident light and ranges in value from 0 to 1 (i.e., albedo comprises multidirectional, diffuse reflections all combined).

This youtube video can help explain albedo and how it is related to global warming: http://www.youtube.com/watch?v=QgzggbEQ2MY

Elaborate

Use the TES Dust Cover Index layer in JMARS to account for the fact that volcanic regions such as the Tharsis bulge appear to have high reflectivity. While much of the terrain is actually basaltic in composition, dust cover gives the illusion of a highly reflective surface.

Explore TES imagery in JMARS and understand albedo.

1. Add the MOLA colorized elevation map for use as context if desired.
2. Add New Layer → Maps By Instrument → TES → TES-Albedo → View graphic data
3. Zoom to a window (2 or 4) that allows the students to differentiate familiar terrain. They can change the transparency of the TES-Albedo map to see the underlying MOLA colorized map to find major geographic regions of interest.
4. Discuss with the students the results of the albedo map. Is anything surprising to them (i.e. Why do basalt/volcanic regions have high reflectivity? See **Explanation**)? What could distort the results?
5. Do students find that albedo maps to be a good indicator of lithology?

Mars for Earthlings

Evaluate

Go to the Kepler: Light Grapher web page:
http://kepler.nasa.gov/education/ModelsandSimulations/lightgrapher/

Using the Light Grapher software and a webcam, measure the amount of light reflected by basalt vs sandstone. This can be done by the following steps:

1. Go to the Kepler: Light Grapher web page and click on "Run LightGrapher".
2. Hold the basalt rock in the camera field of view within the circle of LightGrapher.
3. Make sure that the data capture time is set at 30 seconds then click on "Capture Data". This will begin measuring the amount of light reflected by the basalt.
4. Keep the basalt in the field of view for ~15 seconds then switch to the sandstone for the next 15 seconds. Make sure that the measurement distance for each rock is the same.
5. This will generate a graph that shows the light detected over the 30 second interval.
6. See how students can correlate this activity with albedo as an analogy.
7. You may use other objects with varying color/reflectivity.

To instructors: This is the type of approach you could use. An example of results obtained from this procedure can be found below as well as in the module Image File

Mars for Earthlings

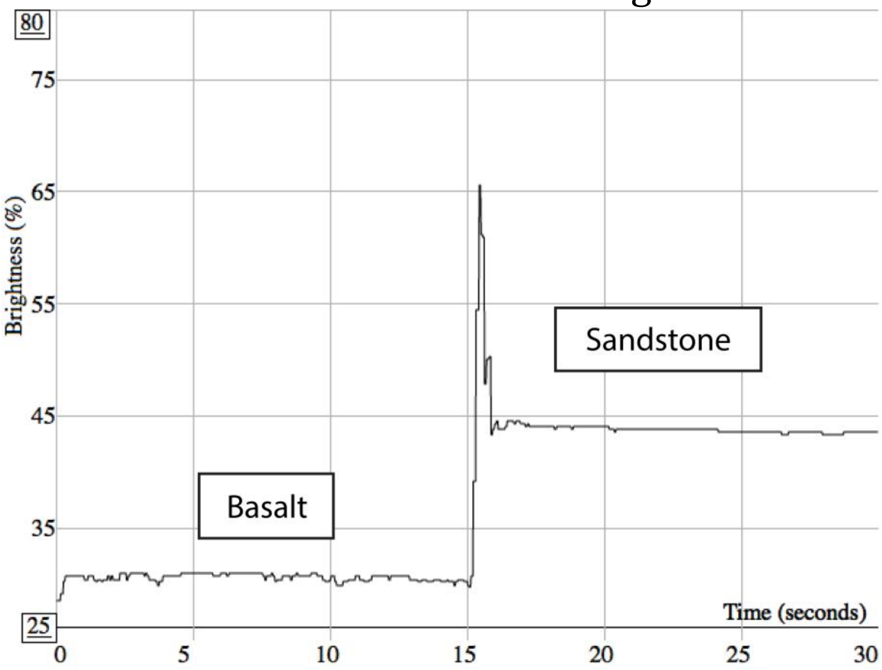

Figure 1. Top left: Vesicular basalt from the Hell's Half Acre Lava Field, Snake River Plain, Idaho; top right: sandstone from the Jurassic Nugget Formation exposed along the Grandeur Peak trail, near Salt Lake City, Utah; bottom: brightness graph generated from 'Kepler: Light Grapher' showing the difference in reflectivity of the basalt and sandstone. The bright peak at ~15 seconds is the change from basalt to sandstone (no rock in field of view).
Images: C. Duncan, University of Utah.

Mars for Earthlings

Homework 1
Life-Hosting Rocks_MFE
The Energy of Rocks

Purpose: Recognize the energy of the environment by its sedimentary structures.

Corn Syrup and Water Experiments
Watch the following videos:

- Flume Experiment: http://www.youtube.com/watch?v=zRGuMddjRGg&list=PL17AFB4B8AB3DCCF7
- Corn-Syrup Experiment: http://www.youtube.com/watch?v=W3YZ5veN_Bg

1. As the students watch the videos, compare/contrast the following parameters:

Parameter	Corn Syrup	Water
Velocity of flow		
Type of structures formed		
High or low energy environment		

The dynamics of sedimentary environments

2. Compare the following environments of deposition according to the following parameters: [Have the students write their answers a-c to the right of the image]
    a. Processes at work
    b. Strength of weathering and/or erosion
    c. Preservation potential of life

Figure 2: Cathedral Cove; Channel Islands National Park, CA. Image: nps.gov

Mars for Earthlings

Figure 3: White Sands National Monument, NM. Image: nps.gov

Sedimentary structures/textures on Mars

3. Similar to Question #3, annotate to the right of each image of Mars below:
    a. What structures do the students see?
    b. What is a likely environment of formation?
    c. Was the environment high or low energy in your opinion?

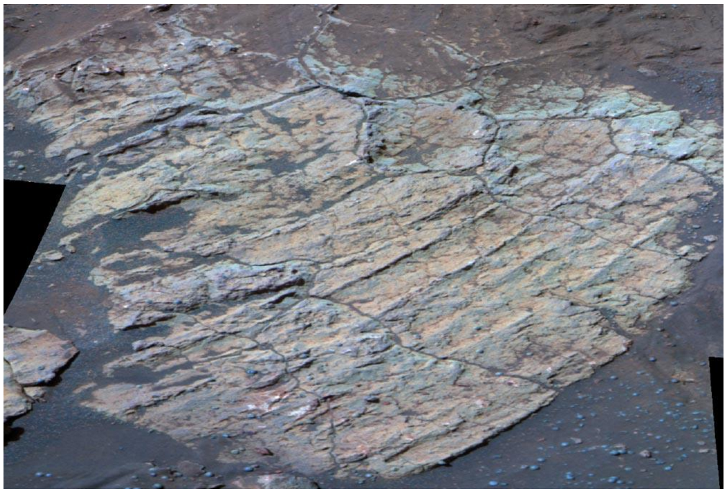

Figure 4: "Escher" rock in Endurance Crater investigated by Opportunity rover; Image Credit: NASA/JPL

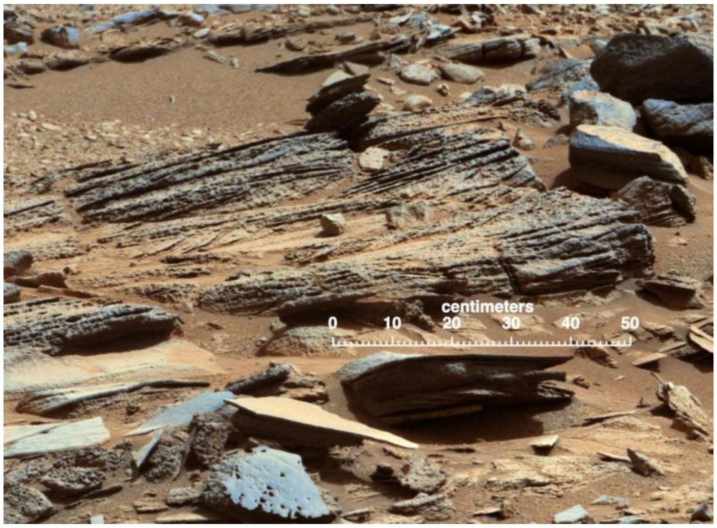

Figure 5: "Shaler" outcrop at Gale Crater investigated by MSL Curiosity rover; Image Credit: NASA/JPL-Caltech/MSSS