Lesson 16: Weathering and Soils

Summary
This module is aimed at helping students understand the patterns and drivers of weathering and the formation of soils on Earth and Mars.

Learning Goals

Students will be able to:

- Differentiate, in photos, between mechanical and chemical weathering processes on Mars & Earth
- Discern, in hand sample, weathered vs. non/lesser weathered material
- Recognize and discern a soil and define soil-forming factors
- Critique the presence of "soil" observations on Mars

Context for Use
It is advisable that students are familiar with basic lithology and mineralogy to be successful in these activities and homework sets.

Description and Teaching Materials
In-Class Activity
In-Class Activity 1: Break a Rock! (need rocks, hammers, and handlenses)
In-Class Activity 2: Is it a Soil?
Homework/Lab
Homework 1: Chemical vs. Mechanical

Teaching Notes and Tips

1. Depending on class size, samples for every student would be advisable to proceed with In-Class Activity 1. With classes size >20 or more students, simply provide a demonstration and have students record the methods and outcomes of what they are observing
2. For In-Class Activity 1 conduct the exercise in a lab environment and/or outside

Assessment
Methods of assessment are within each individual *In-Class Activity* and *Homework*.

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References and Resources:

1. Image File: Weathering and Soils
2. This NASA webpage has a search function for many images related to weathering.
   http://www.jpl.nasa.gov/spaceimages/details.php?id=PIA12994
   e.g., the word "soil" will pull up images of both Earth and Mars
3. Mars "blueberries" spherules NASA announcement:
   http://www.nasa.gov/mission_pages/mer/multimedia/pia16139.html

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In-Class Activity 1
Weathering & Patterned Ground_MFE
Break a Rock!

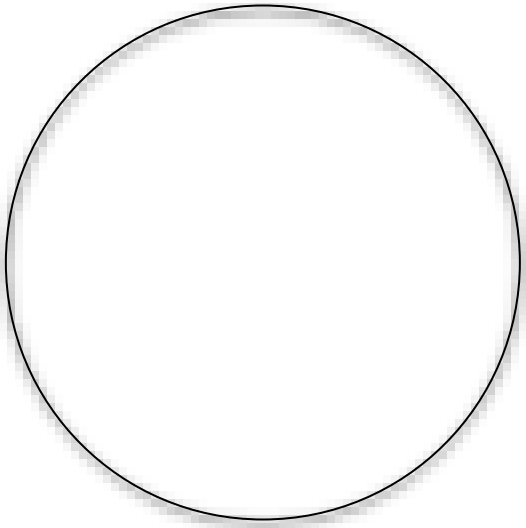
Purpose:
Determine how the physical breakdown of rocks leads to increased rates of weathering and erosion.

Preparation:
Depending on class size the following is need for each student or team of students:

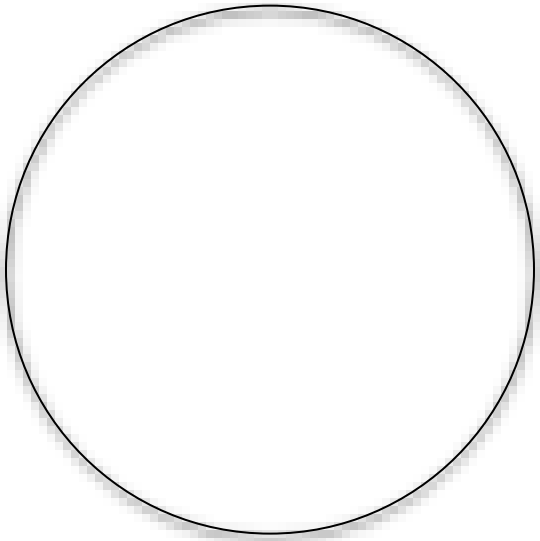
1. Rock hammers
2. Rocks (Geodes would be nice! Otherwise a rock with a weathering rind is good.)
3. Hand lens if possible, but not necessary

Engage
Use the rock hammer and rock provided by your instructor. Break the rock in such a manner that the students can see "the middle" of the rock.

Explore
Have students make a sketch in each circle below of the outside vs. inside of the rock (respectively). Students should note color changes, sizes of crystals, any mottling etc. Be as observant as possible. Also, they provide some sort of scale to understand the relative sizes of sketches.



Outside
Scale:



Inside
Scale:

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Mechanical vs. Chemical Weathering

Consider the sketches, do students see evidence for mechanical weathering and/or chemical weathering? Please list them.

Explain

- The rates of weathering depend on a number of factors, from climate to grain size of the weathered lithology. Help students to recognize these different factors and perhaps what is most influential.
- Have students try to recognize weathered vs. non-weathered material and how it appears in hand sample.

Elaborate

1. Do you think smaller features will experience higher rates of weathering? Why or why not? What determines the "rate"?

2. Considering Figure 1, would the concept "the smaller the better" apply here? Why or why not? Note the scale in the caption.

3. Have students find an internet image of the weathered accumulations of these "blueberries" from other Opportunity explorations and explain what that that means about how an outcrop would erode over time.

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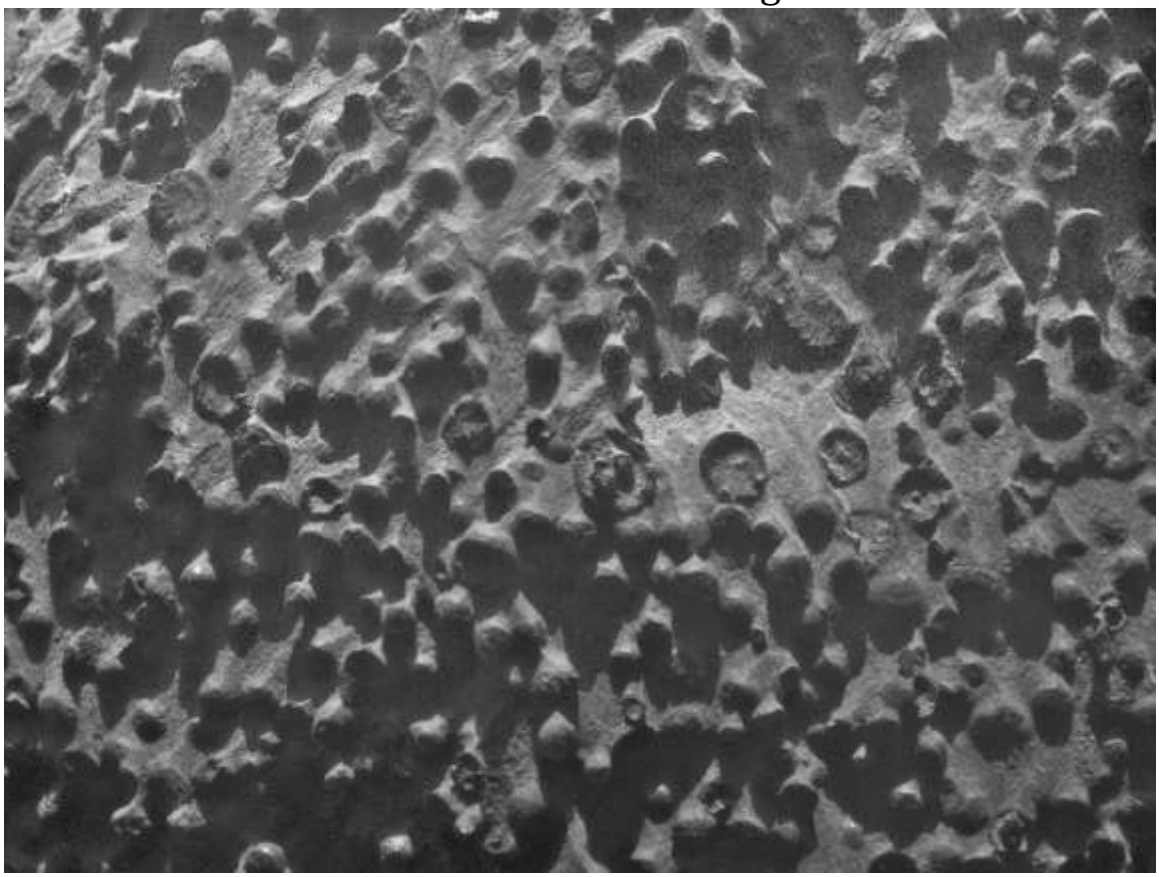

Figure 1: Image taken by rover Opportunity at Endeavor Crater: The view covers an area about 2.4 inches (6 centimeters) across, at an outcrop called "Kirkwood" in the Cape York segment of the western rim of Endeavour Crater. The individual spherules are up to about one-eighth inch (3 millimeters) in diameter. Image Credit: NASA/JPL-Caltech/Cornell Univ./ USGS/Modesto Junior College.

Evaluate

Ask students to list the most important factors in the rate of weathering (name 3 factors).

1.

2.

3.

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In-Class Activity 2
Weathering & Soils_MFE
Soils on Mars?

Purpose: Identify Earth soil horizons and extrapolate what characteristics of soil would be observable on Mars.

Engage
Study Figure 1 below.

1. Does this picture represent a complete soil profile? If not, what horizons are present?

2. What criterion are the students using to define a soil?

Figure 2: A Russian Chernozem (Mollisols in most cases) and the landscape NW of Kursk, in the Kursk Oblast, Russia. Source: http://web.utk.edu/~ammonst/research.html

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3. Brainstorm at least (4) factors that create and form soil on Earth.
    a. Factor 1:
    b. Factor 2:
    c. Factor 3:
    d. Factor 4:

4. Are all factors of equal influence (explain why/why not)?

5. After discussing the soil forming factors, determine which factors exist and/or have the greatest influence on Mars. List and describe below.

Explore

Identifying Soil Horizons

In Figure 2 draw lines and/or labels at horizon boundaries. Indicate if any layers are not present.

O Horizon- thick organic-rich layer
A Horizon- relatively thin organic layer with rooting
E Horizon- leached layer (not always present)
B Horizon- mineral layer
C Horizon- parent material

Figure 3: Image Credit: NRCS Soils

1. What characteristics of this profile might the students observe on Mars? Can they observe it remotely? What do they think gives the yellow layer its color?

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Explain

- The 5 soil-forming factors are: (1) parent materials (2) time (3) biota (4) topography and (5) climate
- In order for a soil to be *classified* as a soil it must have evidence of life and/or plant material
- With regard to general soil horizons: the O-horizon must have a thick layer of organic matter, an A-horizon typically has an abundance of roots and some organic matter, an E-horizon is a leached horizon (of most base-forming cations), the B-horizon is a mineral layer where minerals accumulate, the C-horizon has some characteristics of pedogenesis but still may show structures of the parent material such as bedding, the R-horizon *is* the parent material.

Elaborate

Observe Figure 3 from Mars at Mawrth Vallis, one of the landing site considerations of MSL Curiosity (captured via JMARS):

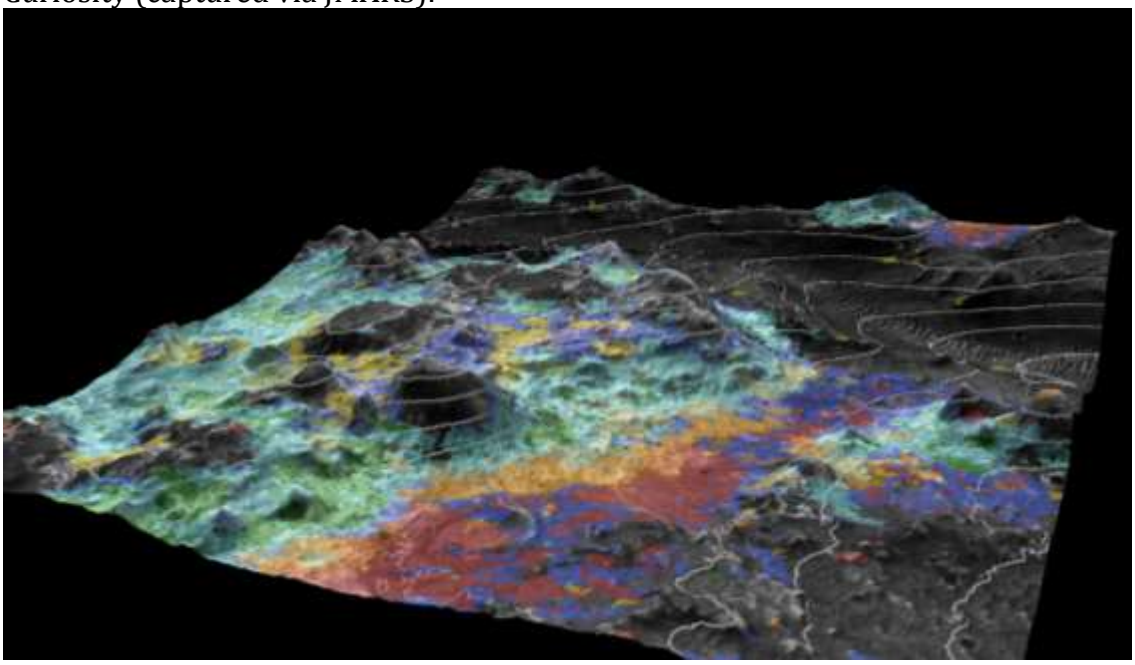

Figure 4: Mawrth Vallis CRISM image overlain on HiRISE imagery. Image Courtesy of Briony Horgan, ASU. Scale of image ~ several km across.

1. What do you observe in this image?

2. Do changes in color follow any discernable pattern?

Evaluation

1. How would students recognize soils on Mars? What would be their criteria?

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Homework 1
Weathering and Soils_MFE
Chemical vs. Mechanical

Introduction: This exercise will focus on the students' ability to identify weathering processes/features on Earth and on Mars. The last part of this exercise will involve using Google Mars to recognize weathering features through high-resolution images.

PART I—Weathering of Earth

For the following 4 images, determine whether they are the result of mechanical or chemical weathering, and identify the specific process that formed the weathering feature.

Sandstone
Australia
Humid continental

Image 1 (Image Source: http://commons.wikimedia.org/wiki/File:Cracked_boulder_DMCR.jpg, "Devil's Marbles" Author: Prince Roy)

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Sandstone
Oregon,
Coastal/temperate

Image 2 (Image Source: http://www.earthscienceworld.org/images/search/results.html?Category=&Continent=&ImageID=hhrhsr#null Photographer: Marli Miller, University of Oregon)

Sandstone
Anza-Borrego Desert State Park,
California,
Semi-arid/rain shadow

Image 3 (Image Credit: Michael Szoenyi/Science Photo Library; http://www.sciencephoto.com/media/173681/enlarge)

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Granite
Enchanted Rock,
Texas
Humid Subtropical

Image 4 (Image Source http://en.wikipedia.org/wiki/File:GeologicalExfoliationOfGraniteRock.jpg)

PART II—Weathering of Mars

For the following images, identify whether the features are caused by mechanical or chemical weathering and answer the additional questions for each image.

Image 5

1. What are 3 likely processes causing the pits in the rock in the image below?
2. What does the pitting process mean for the type of environment that could have existed on Mars?
3. Name 3 geographic areas on Earth that would work as an analog to this rock.

Volcanic rock
Ares Valles region,
Pathfinder landing site

Image 5 (Image Source: http://science.ksc.nasa.gov/mars/mpf/stereo-arc.html)

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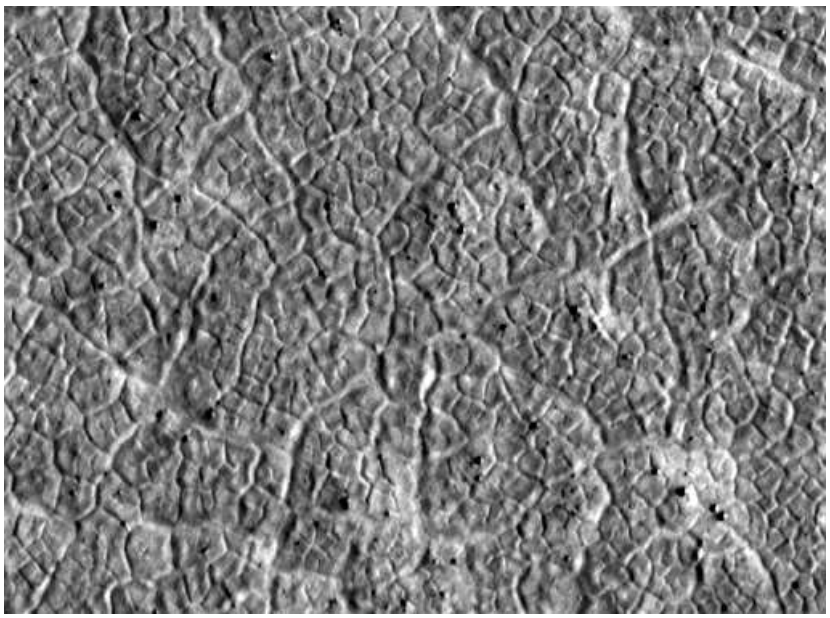
Image 6

1. What feature is shown below?
2. What are 3 processes/influences that can cause these features?



Likely sand-siltstone
Near North Pole

Image 6 (Image Source: http://web.pdx.edu/~pdx06058/Planetary_Research.html)

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Image 7

1. This is a false-color image of the surrounding area around the Sojourner Rover. What is the red tone on the Martian surface and what does that mean?

2. Which direction is the wind coming from (This does not have to do with weathering)?

Volcanic rock (Yogi rock)
Ares Valles region
Pathfinder Lander location

Image 7 (Image Source: http://nssdc.gsfc.nasa.gov/planetary/marspath_images_2.html)

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Image 8

1. What is the nickname given to the little balls scattered in the image below?

2. What are they? How are they formed and what does that mean for surface processes in the Martian past?

3. What weathers faster: the host rock or the little balls scattered on the surface? Give some reasons to support your answer.

Photo by MER Opportunity Rover At rock outcrop "Shoemaker's Patio"

Image 8 (Image Credit: NASA/JPL; Source: http://photojournal.jpl.nasa.gov/catalog/PIA05584)

PART III—Google Mars

1) The images in questions 1 and 3 were taken by the Mars Pathfinder Lander.
   a. Where is the lander located (lat/long)?
   b. Go into the "presidential" panorama and describe the image and features.
   c. It landed in Ares Valles. Describe the area in terms of the geomorphic features and why it presently looks this way.

2) The image in question 2 was taken by the HiRISE camera aboard the Mars Reconnaissance Orbiter. The coordinates are approximately 71° 38' N and 145° 20' E.
   a. What kind of environment would create a surface like this? Is this process continuing today on Mars? Is it continuing on Earth?

3) The MER Opportunity rover took the image 8. Go to the following website:

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http://mars.nasa.gov/mer/home/

Click on Multimedia

- Click on images
- Go to All Raw images for the Opportunity Rover
- Next go down to Science Cameras/Panoramic Camera and scroll down to Sol 109, Click "View Selected Images"
- Scroll down and explore images 8-20 under Sub-Frame EDR (not numbered)

a. Determine why it took so many images of the same spot on the surface.
b. Record the Sol from the latest image (go back one page). How does this Sol compare to the expected life of the mission?

c. Go back to Google Mars and determine approximately where the rover was when it took these pictures, both geographically and lat/long.

d. Go to the panoramic, "Crater of Clues" and have the students briefly describe what they see, both around the rim of the crater as well as within the crater.