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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NASA Award (NNX11AH29G)

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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 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 1: 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 2: 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):

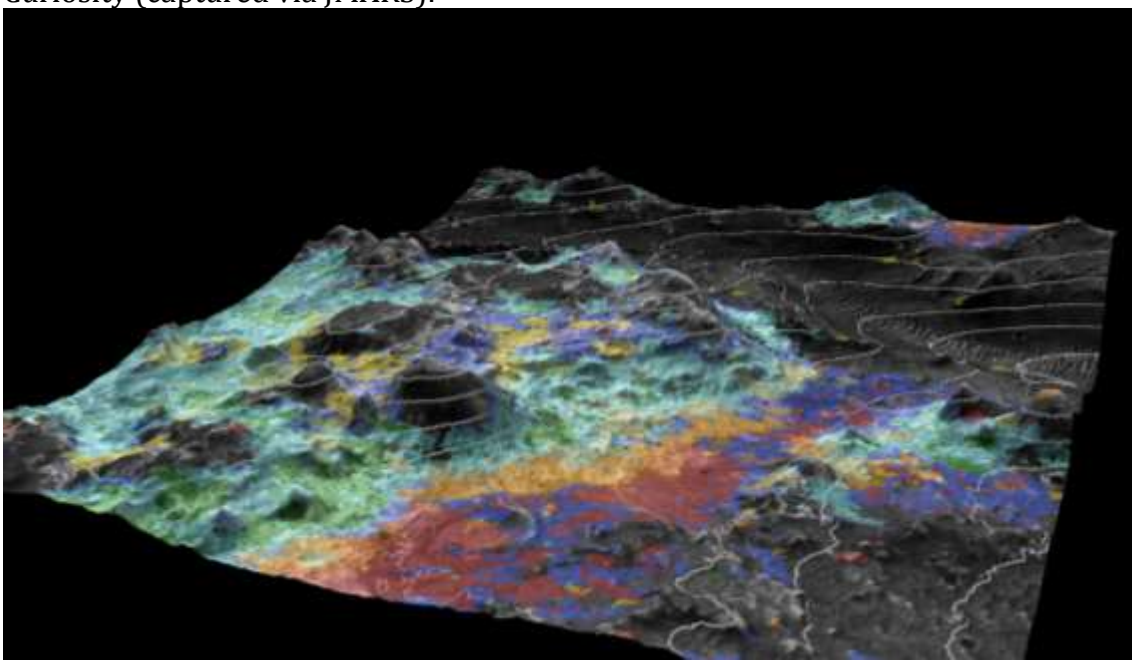

Figure 3: Mawrth Vallis CRISM image overlain on HiRISE imagery. Image Courtesy of Briony Horgan, ASU. Scale of image ~ several km across.

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?