Lesson 17: Vast Deserts on Mars

Summary
Using a Sandbox experiment and Google Earth students will study the formation of dunes and relate their observations to Mars dune field imagery.

Learning Goals

Students will be able to:

- Identify wind current directions on Earth and Mars
- Explain the formation of certain dune morphologies.
- Use Google Earth to identify changing paleocurrent direction, bounding surfaces, and their potential to be observed/preserved on Mars.

Context for Use
This learning module is meant for integrating the Martian wind into terrestrial analysis. The *In-Class Activities* can be easily adapted for homework when desired.

Description and Teaching Materials
In-Class Activity
In-Class Activity 1: Sandbox Dunes
In-Class Activity 2: Martian Ventifacts
Homework/Lab
Homework 1: "Bounding" Through Dunes

Teaching Notes and Tips

1. For larger classes (>20 students) you can either create your own Sandbox Dune demonstration or use the Video demonstration (see Resources).
2. In Homework 1: students will need a clear understanding of how dunes and dune processes are recorded in the rock record (marching away from you, toward you, paleocurrent direction etc.).
3. You will often integrate the Explain and Explore sections of the In-Class Activities. Interact with the students as they "explore" and help them define terms/principles (Ex: Sandbox Dunes).

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

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References and Resources

1. Image file: Vast Deserts on Mars
2. Antarctica Ventifacts
3. Sand Box Dune Video: http://serc.carleton.edu/details/files/44290.html
4. Grotzinger, J.P. et al., 2005. Stratigraphy and sedimentology of a dry to wet eolian depositional system, Burns formation, Meridiani Planum, Mars. Earth & Planetary Science Letters, v. 240, p.11-72.
5. Burns Formation PanCam Sol 288 Image Source: http://marsrover.nasa.gov/gallery/all/1/p/288/1P153752565ESF37MIP2544L7M1.HTML

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In-Class Activity 1
Vast Deserts_MFE
Sand Box Dunes

Purpose: Understand the processes that form sand dunes on Mars and Earth.

Preparation:
1. Build your own Sandbox or download the video of MFE's sandbox demonstration from **References and Resources** of this module for use in the classroom.

Resources:
1. For full resolution images in this *In Class Activity* use the PowerPoint image file (.pptx) for this module located in **References and Resources**.
2. Sandbox video: http://serc.carleton.edu/details/files/44290.html
3. HiRISE Dune Image Source: http://hirise.lpl.arizona.edu/ESP_012202_1390
4. THEMIS Dune Image Source: http://themis.asu.edu/node/5758
5. Mars Global MOLA map: http://mola.gsfc.nasa.gov/images/mercat_med.jpg

Engage
Encourage discussion from students using the following questions:
1. If you were to travel into a valley and see the rocks shown in Figure 1:
    a. What processes are at work in the valley?

    b. What grain sizes are left?

    c. What happened to the rest of the grains?

Figure 1: Death Valley ventifacts; *Photo by Marjorie Chan*

Explore
1. Take the students through a Sandbox demonstration (via video or http://serc.carleton.edu/details/files/44290.html from Mars for Earthlings website, or your own sandbox)
    a. Vary sediment input
    b. Vary wind speed

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   c. Vary surface area or focus of wind source
   d. If possible incorporate varying wind directions to achieve multi-directional dune morphologies
2. Watch the sandbox demonstration and answer the following
   a. How does the surface change?
   b. Which side of the dunes are the steepest? Why?
   c. What happens when the angle becomes too steep? What do we call that angle?
   d. What is the steep side of the dune called?
   e. How does the slip face change through time?
3. View Mars Images
   a. Present students the following Mars Images (see **Resources** in this activity). Indicate where these areas are found on Mars using Google Mars or the annotated image in the Image File for this module).
      i. HiRISE: ESP_012202_1390 Dunes in the Western Nereidum Montes (38.6S, 44W)
      ii. THEMIS: V43323004 Terra Sirenum (39.7S, 150W) is the location of this image. The unnamed crater has dunes on its floor (students will likely have to zoom-in on the image).
   b. Have students discuss the following
      i. What is the prevailing wind direction in each image?
      ii. Are the dunes multi-directional? If so, how can the students tell?
      iii. Is there more than one dune shape/morphology (barchans, transverse, longitudinal, parabolic etc.)? If so, what are they?

Explain

1. As students complete their observations in **Explore** discuss the following terminology in light of their sketches and observations *before they interpret Mars* images.
   a. Angle of Repose
   b. Slip face
   c. Saltation
   d. Deflation and Abrasion
   e. Dune Morphologies (barchans, transverse, longitudinal, parabolic etc.)
2. If possible, have students label these terms in their sketches after they are finished sketching.

Elaborate

Referring to the Mars Images utilized in **Explore**, encourage students to interpret the following about the eolian system:

1. What is the sediment supply like (abundant, sparse)? Have students explain their answer.

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2. According to your knowledge of the geography of Mars and its regions, what might be the source of the sediment (Supply students a copy of a Mars MOLA or project the global MOLA map)?

Evaluate

1. Peer evaluation
    a. In both the Exploration and Elaboration activities, try having students write their answers on cards and pass them to their neighbors
    b. Have their peers agree or disagree with their findings. Given time, have them discuss their findings.
2. The labeling activity in **Explain** will help instructors determine whether or not students comprehend the terms and their use.

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