

Lesson 6: Olympus Mons and Igneous Rocks

Summary

This learning module and related laboratory exercise exposes students to volcanic styles, eruptions, igneous rock textures and their evidence in the Martian landscape.

Learning Goals

Students will be able to:

- Differentiate between pahoehoe and a'a lava flows through USGS video and subsequent discussion. Students will then observe Mars imaging of lava flows and hypothesize which lava flow is more likely on Mars.
- Observe a columnar joint experiment using cornstarch, observe the process and discuss its potential formation on Mars. Students will observe columnar jointing on Mars using HiRISE imaging and compare the features to the Columbia River basalts on Earth as an analog.
- Use Google Mars and JMARS software, students will increase their literacy with the software packages as well as recognize and analyze different mineralogies on Mars and the nature of Olympus Mons in comparison to Earth analog volcanoes.

Context for Use

This learning module is meant for adaptation in an introductory earth science course and/or planetary science course. Before engaging in the In-Class Activities and/or Homework, students will need to be provided with an overview of igneous rocks (see Teaching Notes and Tips). All In-Class Activities can be adapted to a homework set if desired. Online access is essential for video viewing in association with the In-Class Activities.

Description and Teaching Materials

In-Class Activity

In-Class Activity 1: Lava flows

In-Class Activity 2: Cornstarch columnar joints

Homework/Lab

Homework 1: Google Olympus Mons

Homework 2: Basalt & JMARS

Teaching Notes and Tips

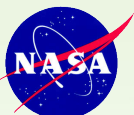
1. Provide students with a background in the rock cycle, igneous rock textures, volcanic styles, and rates of cooling for *In-Class Activity 1*.

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2. Instructors may choose to develop their own cornstarch experiment by the adaptation of the following published experiment and results:
http://www.physics.utoronto.ca/~nolin/papers_mud.html
3. Make sure students are familiar with both Google Mars and JMARS software. The introduction module “Introduction to Mars and Earth Analogs” provide homework and/or In-Class activities to expose and orient students to the software packages.

Assessment

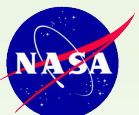
- One of the goals of MFE is to have students become familiar with Mars imagery and navigating the mission online archives as well as software programs available to explore Mars imagery. The homework assignments, if completed, will provide students with increased competence in navigating both Google Mars and JMARS software.
- Through comparison of various Mars images students will be asked to identify common minerals on Mars, their abundance in terms of geographic location, as well as style of igneous rock formation.



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References and Resources

1. Image file: [Igneous Rocks and Volcanics](#)
2. Rock Cycle Background:
http://www.classzone.com/books/earth_science/terc/content/investigations/es0602/es0602page02.cfm
3. Columnar Joint Experiment Video: www.youtube.com/watch?v=CJWfneKdv08
4. Columnar Joint Article:
<http://www.sciencedaily.com/releases/2008/12/081216104325.htm>
5. Columnar Jointing in Columbia River Gorge Oregon:
http://www.youtube.com/watch?v=WLGXmJZ_KIU
6. Mars columnar jointing discovery by HIRISE in Geology:
<http://geology.gsapubs.org/content/37/2/171/F1.expansion.html>
7. HIRIES columnar jointing image:
http://www.nasa.gov/mission_pages/MRO/multimedia/mro20090225.html
8. Pahoehoe lava flow video:
<http://www.youtube.com/watch?v=qTTLyX4Xo2k&feature=related>
9. A'a lava flow video: <http://www.youtube.com/watch?v=bWswq8PmRII>
10. Basalt on Mars (Hawaii): <http://www.psrc.hawaii.edu/May09/Mars.Basaltic.Crust.html>
11. Athabasca Spiral lava flows: Discovery news article: <http://www.space.com/15446-mars-lava-volcanoes.html>
Image source: <http://www.space.com/15446-mars-lava-volcanoes.html>
12. Mars Plagioclase mineralogy animation:
<http://www.youtube.com/watch?v=FRU0cHb31JM>



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In-Class Activity 1

Olympus Mons_MFE

Lava Flows

Purpose: Recognize a pahoehoe vs. a'a lava flow through video, explain why the flows differ, and hypothesize which flow might be more common on Mars.

Resources:

-Pahoehoe lava flow video:

<http://www.youtube.com/watch?v=qTTLyX4Xo2k&feature=related>

-A'a lava flow video: <http://www.youtube.com/watch?v=bWswq8PmRII>

-Mars lava coils: Discovery news article: <http://www.space.com/15446-mars-lava-volcanoes.html>

Engage

1. Have students watch both the pahoehoe and a'a video (see **Resources** above in this *In-Class Activity*). As they are watching, have them record their observations of each flow and how they differ.
2. Discuss student observations of these Earth examples and make corrections where necessary.

Explore

1. Ask students which lava flow, both or neither, would be more common to Mars. Encourage students to substantiate their answers.
2. Following discussion of the above present Figure 1 and ask what type of lava flow is most likely to have formed the below spiral feature (see Image File for higher resolution and original image size):

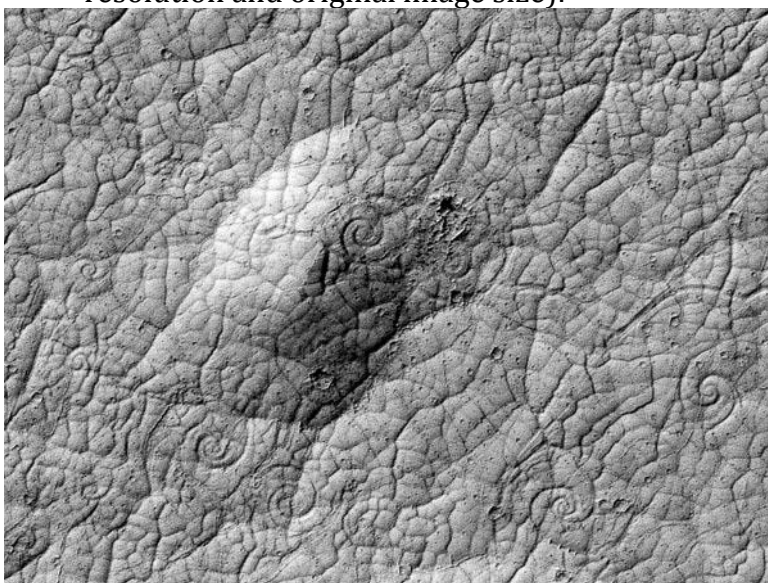


Figure 1: Spirals in Athabasca Valles, Credit: NASA/JPL/University of Arizona, Spirals are 16-98 ft wide.

Image source: <http://www.space.com/15446-mars-lava-volcanoes.html>

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Explain

Divide the class into 2 teams (one pahoehoe, the other a'a) and give them the basic physical characteristics of the two lava types. Their job is to research (e.g. on the Internet) what causes the different physical properties (WHY the two types of lava are different). They should explain how different fluid properties such as viscosity, and crystal and gas bubble content affects their type of flow. Each team can give a short presentation of their lava. Examples and definitions, followed by the processes they should investigate.

Pahoehoe lava- is basaltic lava that has a smooth, billowy, undulating, or ropy surface. These surface features are due to the movement of very fluid lava under a congealing surface crust. A pahoehoe flow typically advances as a series of small lobes and toes that continually break out from a cooled crust. It also forms lava tubes where the minimal heat loss maintains low viscosity. The surface texture of pahoehoe flows varies widely, displaying all kinds of bizarre shapes often referred to as lava sculpture. With increasing distance from the source, pahoehoe flows may change into a'a flows in response to heat loss and consequent increase in viscosity. Pahoehoe lavas typically have a temperature of 1100 to 1200 °C.

A'a lava- The loose, broken, and sharp, spiny surface of an a'a flow makes hiking difficult and slow. The clinkery surface actually covers a massive dense core, which is the most active part of the flow. As pasty lava in the core travels downslope, the clinkers are carried along at the surface. At the leading edge of an a'a flow, however, these cooled fragments tumble down the steep front and are buried by the advancing flow. This produces a layer of lava fragments both at the bottom and top of an a'a flow. A'a lavas typically erupt at temperatures of 1000 to 1100 °C.

Accretionary lava balls as large as 3 meters (10 feet) are common on a'a flows. A'a is usually of higher viscosity than pahoehoe. Pahoehoe can turn into a'a if it becomes turbulent from meeting impediments or steep slopes.



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Elaborate

Of the below rocks pictured:

1. Which are most likely to have formed by igneous processes on Earth?
2. Which by igneous processes on Mars?
3. Make sure students explain their choices in discussion. (Hide caption from students)

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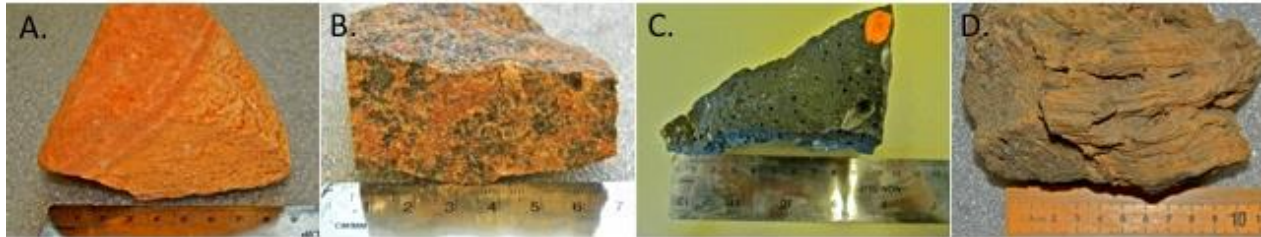


Figure 2: A. Sandstone, B. Potassium Feldspar Granite, C. Basalt, D. Oxidized Basalt

Evaluate

Consider the Spirals in Athabasca Valles (Figure 1). Which rock(s) in Figure 2 would students expect to find in Athabasca Valles? Why?