Mars for Earthlings

LESSON 6: Igneous Rocks & Volcanics

In-Class Activity 1

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:
Mars Lava Coils: Discovery news article: http://www.space.com/15446-mars-lava-volcanoes.html

Pahoehoe and A'a on Earth:
Watch the following YouTube videos:

Video 1: http://www.youtube.com/watch?v=qTTLYx4Xo2k&feature=related
Video 2: http://www.youtube.com/watch?v=bWswq8PmRII

- What are the differences between the two lava flows?

What is possible on Mars?

1. Consider both the pahoehoe and a'a lava flows. Which lava flow do you think is more common to Mars? Substantiate your answers.

2. Figure 1 is a volcanic feature on Mars. What type of lava flow formed this feature? Explain your reasoning?

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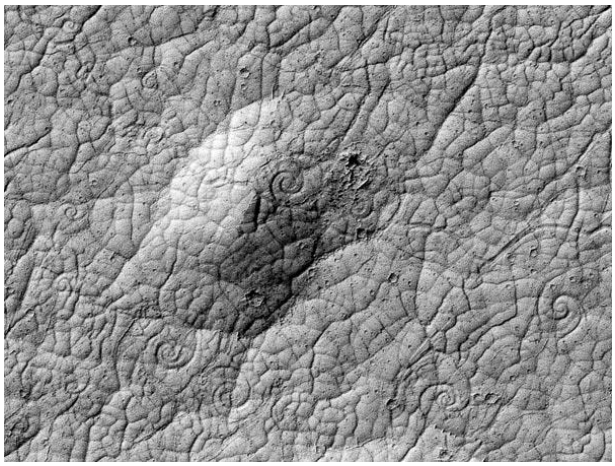

Figure 1: Spirals in Athabasca Valles, Credit: NASA/JPL/University of Arizona, Spirals are 16-98 ft wide. Image source: http://www.space.com/15446-mars-lava-volcanoes.html

Understanding volcanic rocks

Of the rocks pictured below in Figure 2:

1. Which rocks are more likely to have formed by igneous processes on Earth?

2. Which rocks are more likely to have formed by igneous processes on Mars? Explain your reasoning.

3. Is it likely that any of the rocks pictured below could be found in Athabasca Valles (Figure 1)? Why or why not?

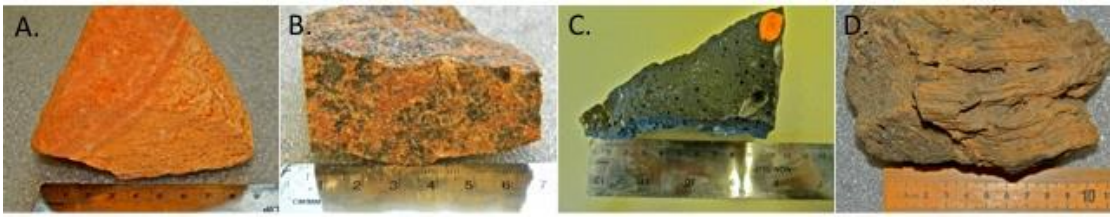

Figure 2

Image Credit: Levi Huish/University of Utah)

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In-Class Activity 2
Igneous Rocks & Volcanics_MFE
Columnar Jointing on Mars

Purpose: Become familiar with the formation and the processes of columnar jointing and its apparent formation on Mars.

Are these columns natural?
Study Figure 1 (a) below. A. In a few sentences, write down your hypothesis for how these features form. B. Are there any other features in your daily life or on Earth that have similar characteristics?

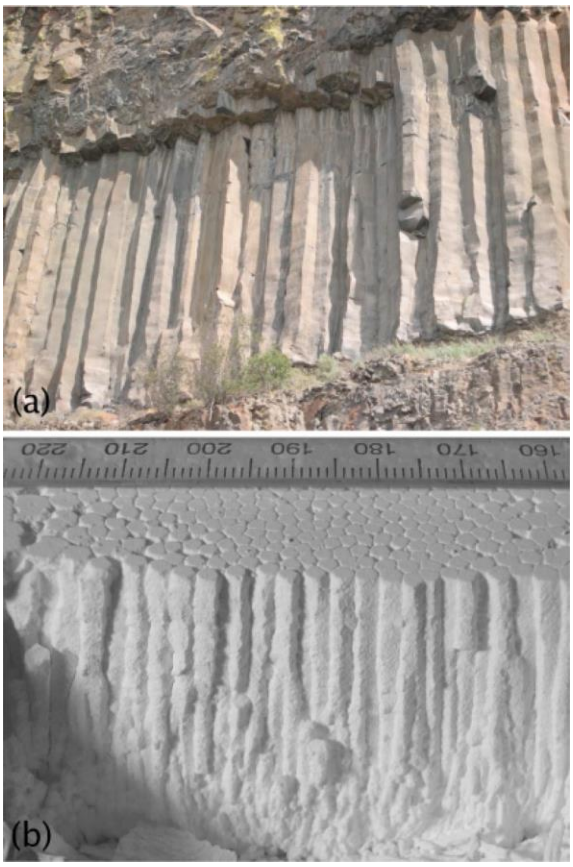

Figure 1 Columnar jointing in (a) basalt of the Columbia Plateau near Banks Lake ~95 cm average diameter, and (b) in desiccated corn starch. (Image Credit: Gohering L., Morris, S.W., and Lin, Z., 2006. Experimental investigation of the scaling of columnar joints. PHYSICAL REVIEW E 74, 036115, p. 1-12.)

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Watching columnar jointing in action:
Read the following article or view the following cornstarch experiment video used to illustrate columnar jointing (Figure 1 (b) is a still from the experiment). Consult the explanation under the video window.
Video: www.youtube.com/watch?v=CJWfneKdv08
Article: http://www.sciencedaily.com/releases/2008/12/081216104325.htm

1. Is there perfect similarity between the "real" columnar joints of the Columbia River basalts and the experiment? Why or why not?

2. How do the fractures/cracks form? Are they widening, re-forming through time, or starting new fractures?

3. What might enhance the cracks?

4. How could you foresee such features forming on Mars?

A Discovery!
View the following 2009 Mars discovery:

1. **Figure 2** (below) shows images of columnar jointing on Mars using the HiRISE camera (see original HiRISE link). Using arrows, point to where you think the columnar joints are exposed in this terrain.

2. What does this image tell you about igneous rocks and their history on Mars?

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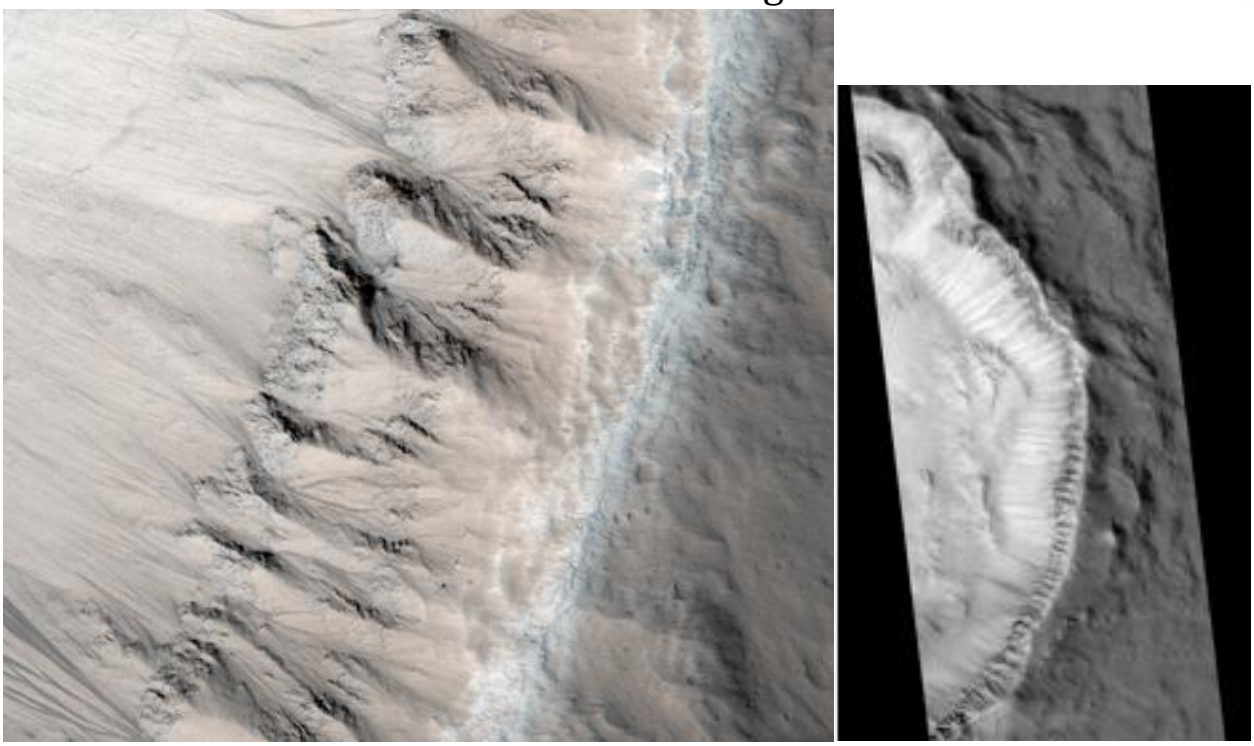

Figure 2 http://hirise.lpl.arizona.edu/PSP_005917_2020 **(Image Credit: NASA/HiRISE)**

References:

Goehring, L., et al., 2008, Nonequilibrium scale selection mechanism for columnar jointing, PNAS, V. 106, p. 387

Goehring, L. and Morris, S.W., 2008, Scaling of columnar joints in basalt, JGR-Solid Earth, v. 113, pp. B10203

Iddings, J.P., 1886, Columnar structure in the igneous rocks of orange Mtn., N.J.: American Journal of Science, v. 131, p. 321-330.

Iddings, J.P., 1909, Igneous Rocks: Wiley, New York.

Long, P.E., and Wood, B.J., 1986, Structures, textures, and cooling histories of Columbia River basalt flows: Geol. Soc. America Bull., v. 97, p. 1144-1155.

Mallet, R., 1875, Origin and mechanism of production of prismatic (or Columnar) structure in basalt: Phil. Mag. v. 4, p. 122-135 and 201-226.

Milazzo et al., 2009 Discovery of Columnar Jointing on Mars; *Geology* 2009;37;171-174 doi:10.1130/G25187A.1

Spry, A., 1962, The origin of columnar jointing, particularly in basalt flows: Journal of the Australian Geological Society, v. 8, p. 192-216.

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Homework 1
Igneous Rocks & Volcanics_MFE
Google Olympus Mons

Purpose: Explore Olympus Mons using the Google Mars platform through HiRISE imagery and Colorized Terrain maps.

Preparation: Download Google Earth 6
http://www.google.com/earth/download/ge/agree.html

Directions/Questions:

Navigate to Olympus Mons

1. Open Google Mars (click on the planet with a ring)
2. Turn on the Global Maps Layer *Colorized Terrain*
3. Navigate to Olympus Mons- the tallest point on Mars
    a. What is the elevation of Olympus Mons?
4. Activate the *HIRISE Image layer* under the Spacecraft Image Layer Folder

Analyze Olympus Mons Images

5. Zoom in to the top of the Olympus Mons Caldera
    a. Find image PSP_004821_1985 from HIRISE [near the Hiker icon]
    b. Sketch what you see in the image below.

    c. What might you be seeing? Consider the context image of the Colorized Terrain map and list your observations.

6. Find image PSP_004531_1990: NW flank of Olympus Mons (note the compass in the upper right ~ 15-18km elevation, 18.56N 224.28E)
    a. Sketch what you see in the image below.

b. Can you make some interpretations about what you are observing?

Comparing Olympus Mons and Earth Analogs

7. Of the volcanic styles (mafic vs. felsic), which volcanic type fits Olympus Mons the best in your opinion? Explain your choice and why Olympus Mons cannot be classified as the other choices.

8. If you wanted to be sure about your volcano classification, what additional data would you need to confirm your choice in #7?

9. What volcano on Earth serves as the best comparison to Olympus Mons (you may need to do some outside research to answer this question adequately)?

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Homework 2
Igneous Rocks & Volcanics_MFE
Basalt & JMARS

Discussion/Questions

1. The following are common igneous/mafic rock forming minerals. For each mineral, list its chemical formula:
    a. Olivine

    b. Pyroxene

    c. Amphibole

    d. Biotite

    e. Plagioclase (anorthite)

2. Compare the chemical formulas and their elements to the element abundance list for Mars below. Which minerals do you think will be more common on Mars? Please explain your choices below next to the list.
    1. oxygen
    2. silicon
    3. iron
    4. magnesium
    5. calcium
    6. aluminium
    7. sodium
    8. potassium
    9. chloride

3. Open JMARS. Using the *Nomenclature* layer, zoom to Valles Marineris to gain your geographical bearing. Add and compare the following layers (Add New Layer → Maps by Instrument →TES Mineral Maps): Basalt Abundance, Plagioclase Abundance (Bandfield, 2002), any olivine abundance map, and Carbonate Abundance. Warmer colors denote greater abundance.
    a. Which map has the most coverage? Why might this be? What complications might arise from collecting this type of data? Could anything distort the data?

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b. Where does the abundance of Plagioclase generally increase on the surface of Mars? Use geographical points of references or lat/long to explain.

c. Compare the following animation for plagioclase abundance on Mars to the JMARS mineral map. Which perspective do you prefer?
http://www.youtube.com/watch?v=FRU0cHb31JM

d. Are you surprised about the abundance of plagioclase on Mars in comparison to other minerals? Why or why not?