Using sand dunes to interpret geologic processes on Mars

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Introduction

Erosion/modification is a major geologic process that operates on all planets. Eolian processes play an important role in the modification of landscapes by eroding, transporting, and depositing sediment as sand dunes. The study of sand dunes is a standard part of the introductory Physical Geology lecture and lab course curriculum for majors and non-majors, but is often taught using illustrations rather than real data. Mars imagery provides geology instructors with a unique opportunity to use sand dunes to interpret geologic processes. Photographs of the geologic features of Mars are ideally suited for this purpose since they provide high quality and resolution, are large in scale, and are unobstructed by vegetation or development.

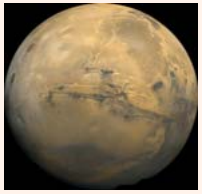


Fig. 1. Photo mosaic image of Mars taken July 16, 1995. The prominent feature at the center of the image is the entire east-west trending Valles Marineris canyon (the largest known chasm in the solar system) which is over 1,864 miles long and 5 miles deep. Image Credit: NASA,Viking Project, USGS.

Objectives

At the end of this activity, students will be able to refer to locations on Mars (Olympia Undae, Nili Patera, Meroe Patera, the North Polar Cap) and:

- Identify the type/s of sand dunes;
- Determine the prevailing and local wind direction/s;
- Identify plausible source/s of the sand dunes.

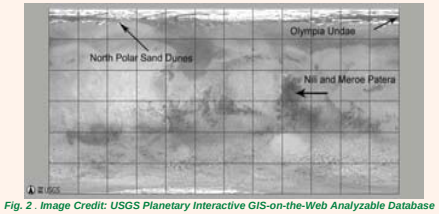


Fig. 2 . Image Credit: USGS Planetary Interactive GIS-on-the-Web Analyzable Database (PIGWAD)Map of Mars. **The map shows the locations of sand dunes used in this activity. The large dark area that includes Nili and Meroe Pateras is the Syrtis Major Planum. Figs. 2a and 2b, and 2c are close-up images of the locations.**

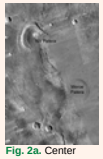


Fig. 2a. Center Locations: Nili Patera; 9.0 N 67.4 E; Meroe Patera 7.0 N 68.1 E.

Fig. 2a

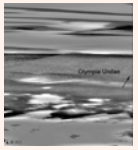


Fig. 2b. Oblique view of Olympia Undae. Center Location: 81.4 N 180 E.

Fig. 2c. Oblique view of North Polar Sand Dunes. Center Location: 76.87N 253.81 W.

Background

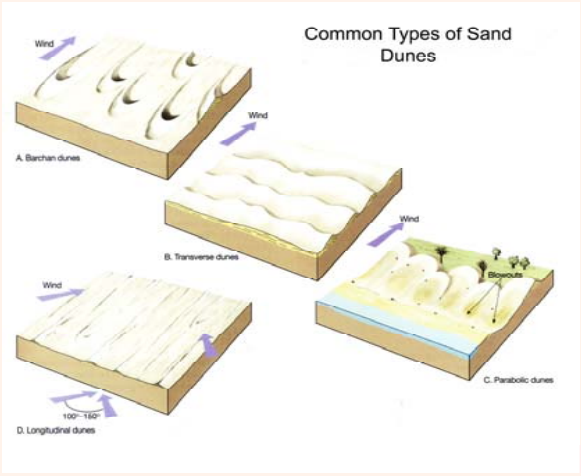


Fig. 3. Image Credit: Busch, Richard M. (Ed). (1993). Laboratory Manual in Physical Geology (6th ed.). New Jersey, Pearson Education.
The diagram above illustrates the common types of sand dunes and the geometric shapes formed relative to wind direction. (A) Barchan dunes are crescent shaped dunes that form where there is a limited sand supply. Barchan dunes typically form around shrubs or large rocks and the horns point downwind. (B) Transverse dunes form in areas where the sand supply is great and form ridges perpendicular to the prevailing wind direction. (C) Parabolic dunes are similar to barchan dunes except that the horns point upwind. Parabolic dunes typically form adjacent to blowouts (depressions). (D) Longitudinal dunes (seifs) occur where there is an abundance of sand and cross winds merge. Longitudinal dunes can grow as large as 200 km (124 miles) long and 100 m (328 ft.) high.

Mars Nomenclature

Planetary nomenclature is used to identify the features on Mars. A brief explanation of the nomenclature for the Mars features used in this activity is provided below.

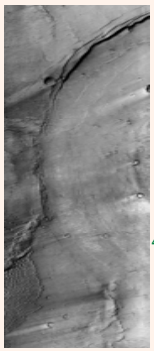
Patera. Patera is derived from Latin and used to designate an irregular crater or a complex crater with scalloped edges.

Undae. Undae is used to designate dunes.

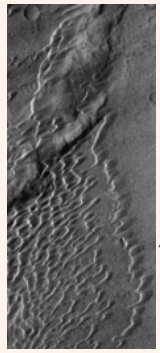
Planum. Planum is used designate a plateau of high plain.

Planitia. Planitia is used to designate a low plain.

Mars Sand Dune Images



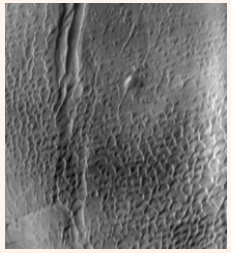
4a.



4b.

Fig. 4. Meroe Patera sand dunes pictured in lower left of fig. 4a. Close-up of sand dunes in fig. 4b. THEMIS image credit: NASA/JPL/Arizona State University.

5a.



5b.

Fig. 5. Nili Patera sand dunes pictured in lower center part of fig. 5a. Close-up of sand dunes in fig. 5b. THEMIS image credit: NASA/JPL/Arizona State University.

Fig. 6. Olympia Undae sand dunes in North Polar Sand Sea. Location: 80.3 N, 172.1 E. THEMIS image credit: NASA/JPL/Arizona State University.

Fig. 7. North Polar sand dunes. Location: 76.87N, 253.81 W. MOC image #45202.

Description of Activity

After reading the background references, students will examine the Mars sand dune images and complete Parts I and II. Note: The activity may be modified and maps prepared in advance by the instructor depending on the technological skills of the students.

Part I

1. **Download and print out a global map of Mars that contains latitude and longitude coordinates from the USGS Map-a-Planet website http://pdsmaps.wr.usgs.gov/.**
2. **Go to the USGS Planetary GIS Web Server PIGWAD http://webgis.wr.usgs.gov/pigwad.htm and select Mars Notice that the latitude and longitude coordinates are displayed as you move the cursor over the map.. You can click on this map to find the coordinates for the sand dune images for Nili and Meroe Patera, the North Polar Sand Sea, and Olympia Planitia. Establish the coordinates for a map that covers an area large enough to print an 8x10 inch map for each of the sand dune images.**
3. **Create your maps using the USGS Map-a-Planet website. By using the intermediate feature, you can input the coordinates needed to create a custom map. Use the customized individual maps and the global map to draw on and make notes as needed to answer the questions in Part II.**

Part II

1. **What type of sand dune/s are visible?**
2. **What is the direction/s of the prevailing wind/s?**
3. **What are the sands composed of?**
4. **What is the likely origin of the sand dunes?**

References

Busch, Richard M. (Ed). (1993). *Laboratory Manual in Physical Geology (6th ed.). New Jersey, Pearson Education.*

Greeley, R. and Iversen, J.D. (Eds.). (1985). Wind as a Geological Process Earth, Mars, Venus, and Titan. Cambridge, MA: Cambridge University Press.

http://www.msss.com/mars_images/moc/8_7_98_n_erg_rel/, MSSS-MOC Spring Time View of North Polar Sand Dunes.

http://themis.asu.edu/features/polardunes, THEMIS North Polar Sand Sea.

http://themis.asu.edu/zoom-20050414a, THEMIS Nili Patera Dune Field released 14 April 2005.

http://themis.asu.edu/zoom-20020809a, THEMIS Meroe Patera Dune Field released August 2002.