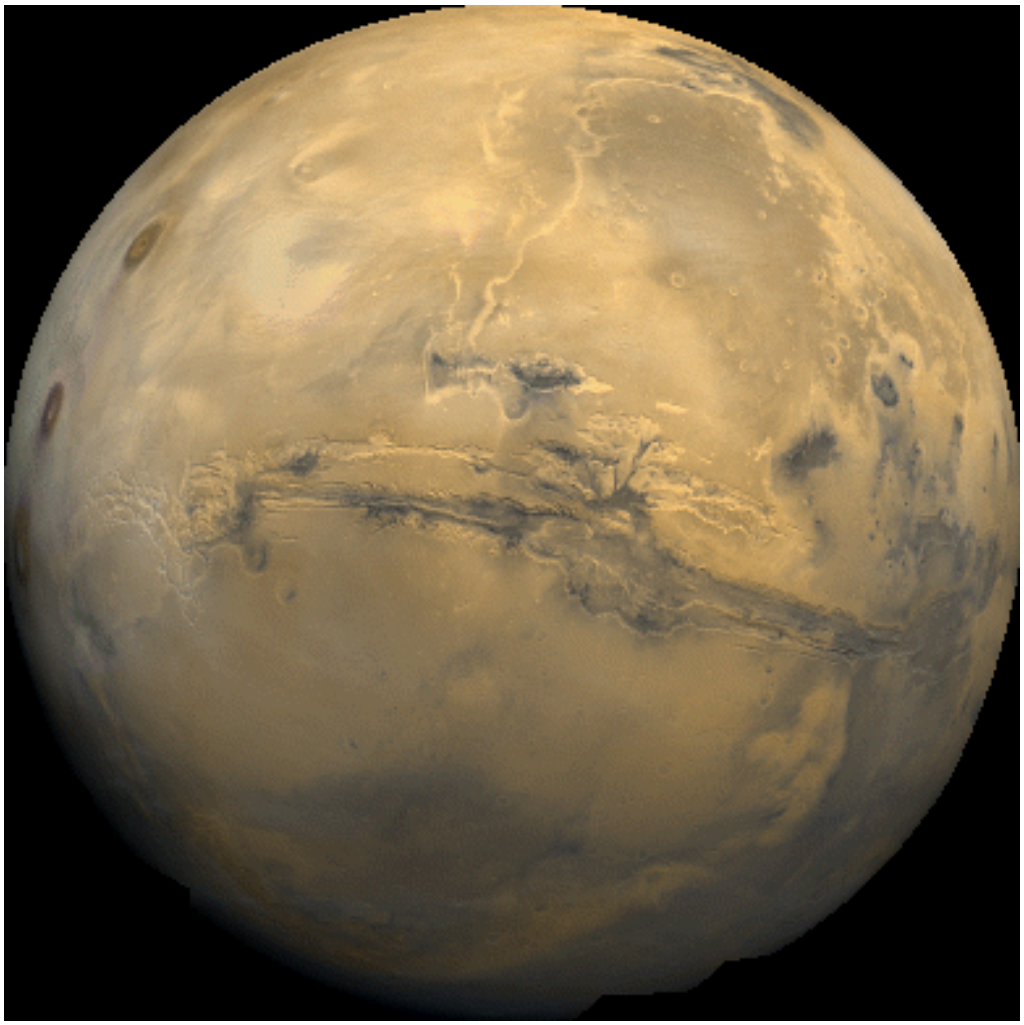
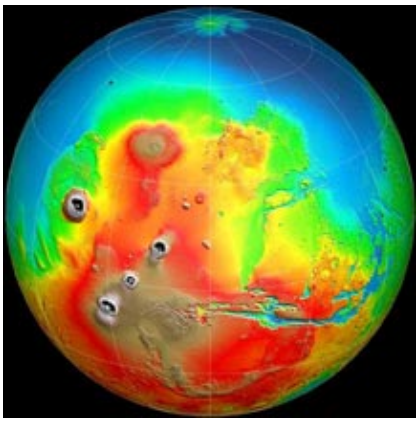
MARS



Lesson 2 - Topographic Mapping of Mars Using Mars Orbiter Laser Altimeter (MOLA) Data



Topographic Mapping of Mars Using Mars Orbiter Laser Altimeter (MOLA) Data

Objectives:

- Creation of a planetary surface based on knowledge of geologic landforms
- Creation and interpretation of a topographic map
- Compare and contrast map with actual known terrain model
- Presentation of results to peers

AZ Standards:

- **1SC-P1**. Propose solutions to practical and theoretical problems by synthesizing and evaluating information gained from scientific investigations
- **1SC-P2**. Compare observations of the real world to observations of a constructed model

Grade Level: All

Time needed: 3 or 4 class periods

Introduction:

Display *Overhead 1*, showing **topography** of Mars from the Mars Orbiter Laser Altimeter **(MOLA)**, and tell students that planetary scientists can determine surface elevations on other planets by using instruments called **altimeters** (see the Mars Introduction in this packet for more information). Altimeters measure how high or low a surface is relative to sea level on Earth and the **datum** elevation on planets such as Mars. The Mars Global Surveyor spacecraft has an instrument on board called the Mars Orbiter Laser Altimeter (MOLA). MOLA sends infrared laser pulses down to the surface of the planet and waits for each pulse return. Based on the angle of return and the time it takes a pulse to return, distance to the surface is obtained. Bounce a tennis ball off the floor and then off a desk to demonstrate how distance effects return time.

Discuss planetary processes and the geologic landforms that result from these processes (planetary processes and landforms are discussed in the Astrogeology Resource Packet in the Planetary Processes section). A combination or series of landforms makes up landscapes.

Make a list of different landforms on the board. This may include:

Mesas
River channels
Plateaus
Rift valleys
Volcanoes
Mountain belts
Impact craters
Deserts/sand dunes
Plains
Shorelines
Lacustrine/marine basins

In this lesson students will pretend that they are part of a crew that is about to land on Mars. They must find a safe and flat landing spot. In Part 1, before they know that they are part of the first colonization crew, students will create a planetary surface out of Play dough incorporating several of the landforms mentioned above. Surfaces will be made inside the plastic boxes provided. The lid of the box has a grid with holes punched in each square. After creating a surface, student groups will switch boxes and map an unknown surface by placing a stick in each hole and measuring the length of stick above the lid at each hole. Student's will then make a topographic or elevation map of their model.

Materials:

- Boxes with lids (provided)
- Colored pencils or crayons
- Measuring sticks, colored - elementary and uncolored - secondary (provided)
- Rulers, 6 (provided)
- Pencils, pen, vis-a-vis markers
- Play dough (provided, to make more see recipe at the end of this lesson)
- Other objects such as blocks, bowls, etc.
- Master grids and scratch grids (provided)
- Reference cards: elementary or secondary level (provided)
- Wax paper (provided)
- Tape
- Tennis ball (provided)
- MOLA data sheets for final project, 11 (provided)

Procedure:

Part A: Creating a Terrain

1. Go over introduction with the students.
2. Divide students into groups of 4 or 5.
3. Supply each group with a box and gridded lid, wax paper, tape, and Play dough. Grids for younger students are marked within the whole with fewer squares.
4. Tape wax paper to the inside bottom of the each box.
5. Students will work together to design a surface or terrain in their box using the Play dough and any other objects that you can think to add. Use the landforms listed above to design the terrain. After terrain is made, have students tape their lid to the box. Each box will have a number, make sure the students write down the number of their terrain box.
6. Let boxes sit overnight.

Part B: Mapping a Terrain

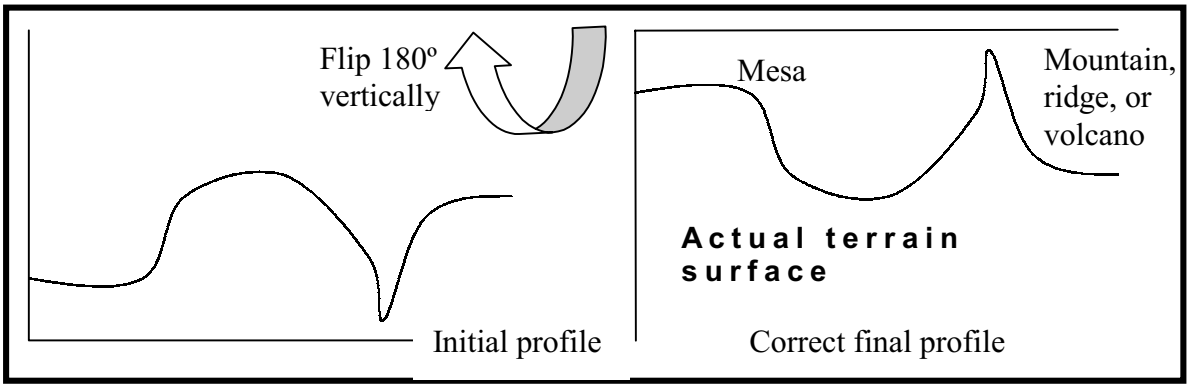
7. Introduce the concept of topographic mapping. The students may become frustrated, so the instructor should plan on being available all class period for guidance and facilitation of lesson.
8. Next class, pass out the Student Sheets and explain that the students are the first human colonizers of Mars and that they must find a safe, FLAT landing spot for their spacecraft.

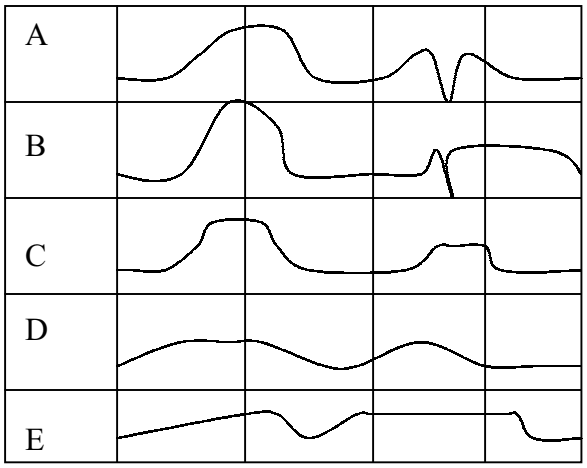
9. Students should return to the same groups they had for the first part of the lesson and choose a boxed terrain to analyze. If there are several periods doing this lesson at the same time, have each class use boxes from another class period. Pass out one topographic map Master Grid per group and a scratch grid for each member of the group, reference cards, measuring sticks, rulers, and colored pencils or crayons. Have students write the number of their box in the space provided on the master grid and on their scratch grids.
10. Students will measure distance to the ground by slowly lowering their stick into each grid hole on their box top. Older students will use uncolored sticks and measure the length of stick remaining above the lid. Round that measurement to the nearest centimeter and write it down in the corresponding box on the scratch grid. Younger students will use the colored sticks and smaller grid marked within the box lids and master/scratch grids. They will write down the number of the color showing where the stick intersects the hole in the box using the reference card to match color and number.
11. Each student in a group can take measurements of a certain portion of the model to allow more time for data analysis at the end of the lesson. After the scratch grid has been filled in, students will transfer these measurements to their Master Grid. Numbers should be written small and neatly in the center of each grid box. See example below.

5	**5**	**4**
2	**3**	**4**
2	**3**	**5**

The other scratch grids will be used to create contour maps of the terrain (Part 3).

OPTIONAL: At this point, groups may create vertical profiles of their unknown terrain for several or all rows of their grids. If this is done it is important to remember how group measurements were taken. For example, if the group measured the amount of stick above the box lid, then the profiles must be flipped over to attain the correct profile.





Examples of profiles taken across grid rows

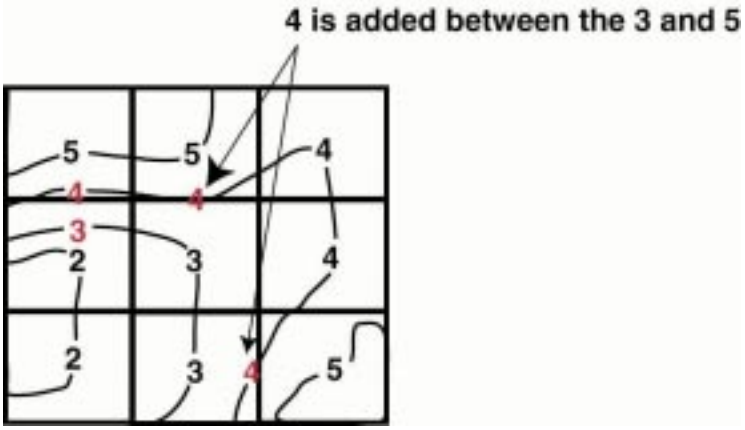
Students can cut the profiles out and stand them up in series to get a 3-D view of their terrain. Doing this gives a visual sense of what their terrain looks like across distance.

Part C: Interpolating a Terrain - Smoothing Out the Data

12. Set aside Master Grid and use scratch grids. If adjacent squares are not in sequential order (i.e. a 2 next to a 4) have the students fill in the missing number between (interpolate) as shown below in red. Now there are no sequencing gaps.

5	5	4
3 2	3	4
2	3	4 5

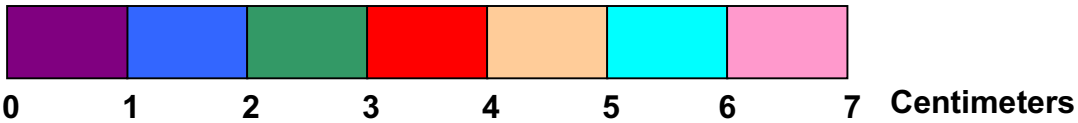
13. Show *Overheads 2a and 2b* and discuss contour lines and interpolation. A topographic or elevation map is comprised of contour lines which connect points of equal elevation. In other words, all points on a particular contour line have the same elevation. Contour lines are always closed polygons or circles. They never just stop without connecting back to themselves unless they are heading off the map edge.
14. Older students will draw contour lines by connecting points of equal elevation as measured earlier. All lines must either start and stop at the edge of the grid <u>or</u> must be an enclosed circle or polygon.



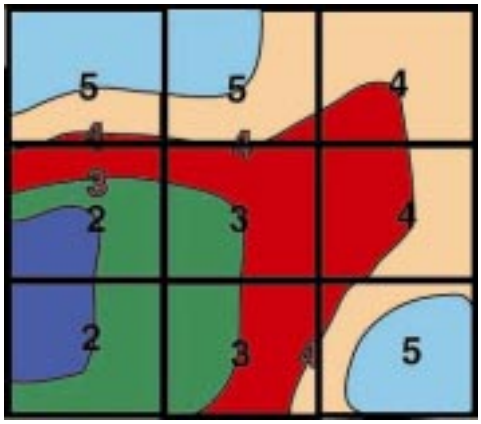
15. Younger students will color in the boxes according to numbers/colors on the reference card. Have them outline each colored area. They have created their own elevation map of an unknown terrain.

5	5	4
2	3	4
2	3	5

16. Older students will design an elevation scale similar to the one below after they create the contour lines. The template is located at the bottom of the Master and Scratch grid. Older students may also use colored sticks and reference cards if needed.



17. Decide on a final topographic map for the group. Transfer the elevation information to the Master Grid and color the map to make a Digital Elevation Map (DEM). DEMs are created from the raw data received from MOLA. The finished map should look similar to the one below.



When the DEM is complete, have student's mark where they agree to land their spacecraft. Also, have students label features on the map (i.e. mountains, impact craters, river valleys, mesas, etc…).

Closure:
Once maps are labeled, students may open the terrain boxes and see how their maps compare to the actual terrain. After the groups have compared terrain, have them use a different color marker to designate a new landing spot if need be and reevaluate what the actual landforms were. On the back of the maps, have them describe why their maps did not include some of the smaller landforms. The answer to this is that the resolution of their map is too low, that is, the holes in the box lid were spaced too far apart. If they were closer together, the map would show more data thus being higher resolution. The MOLA instrument gathers high-resolution measurements.

Each group will then elect one member to present their results to the rest of the class. After all presentations, the class will discuss and chose from all the boxes the best place to land their spacecraft. They can discuss important issues in determining landing sites such as proximity to volcanoes or steep cliffs, etc…

Assessment/Homework:
Each student will complete a final project using real data from the Mars Orbiter Laser Altimeter (MOLA). Eleven MOLA images are included in this lesson. They will analyze the data, answer questions and turn in a report. Students also turn in their group Master Grid and terrain model box.

Extension:
After the lesson is complete, have students match terrain models with the correct topographic map. If more than one class period is doing the lesson, have each period use another period's models and maps.

Remediation
Some student's may need more help because some terrains will be more difficult to map than others.

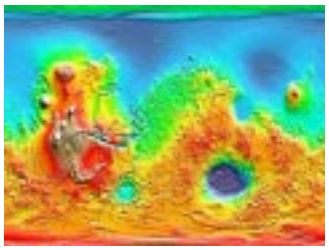
Vocabulary:
Topography, altimeter, datum, MOLA

References:
Lebofsky, Larry A. **Venus Topography Box**. Lunar and Planetary Laboratory, University of Arizona, Tuscon, AZ.
http://ltpwww.gsfc.nasa.gov/tharsis/Mars_topography_from_MOLA/. The Topography of Mars by the Mars Orbiter Laser Altimeter (MOLA)

Additional Resources:
http://education.jpl.nasa.gov/educators/venus_s.html
http://earthview.sdsu.edu/trees/topohans.html
http://www.stanford.edu/group/CPIMA/education/EDKIT/html/probe1.htm
http://ltpwww.gsfc.nasa.gov/tharsis/mola.html
http://academic.brooklyn.cuny.edu/geology/leveson/core/linksa/elevation.html

Play dough Recipe:
1 cup flour
½ cup salt
1 Tablespoon oil
2 teaspoons cream of tarter
1 cup water
Food coloring

Mix all ingredients in saucepan. Heat on low, stirring constantly until dough is evenly mixed and forms a ball. Knead slightly. Store in an airtight container or plastic baggie.



Topographic Mapping Student Sheet

Name_____

M E M O R A N D U M

DATE: May 28, 2003

TO: All Crew Members

FROM: Crew Leader

RE: Spacecraft Landing Location

You are the first humans about to colonize Mars. You are currently orbiting above the planet in your spacecraft. Your crew needs to find a safe, flat place to land and set up your base. Consult your onboard laser altimeter to gather elevation data from several regions across the planet. Since there is too much data for one person to analyze, your crew has split into groups to expedite or make your analysis faster. Each group will survey one region, construct a map and determine the best place to land in that region. Each group will then present their analysis to the rest of the crew (the class). The crew will then vote on the best landing place from all of the maps, and then we will be on our way.

Follow directions from your crew leader (your teacher) on how to go about gathering the elevation data required as well as the equipment needed. After your group has gathered the data, you will use it to construct an elevation map of your region. Use this map to choose the safest and flattest landing spot. After the crew has discussed options and come to a final decision, complete a final report (guidelines follow) and turn it in to your crew leader (your teacher) along with your group's elevation map and terrain model box.

Lets get to work, and happy hunting!!!

Final Project Report - to be turned in by each member of your group.

Directions:
Your group will be given an elevation map of Mars that was created using real data from the Mars Orbiter Laser Altimeter. Look at this region of Mars and find the best spot for landing a spacecraft. Each map has an elevation scale attached so you can determine how high or low features are and also the slope or gradient of the surface. Remember, you want to land on a FLAT surface. Use the marker that you receive with the map to circle your landing area.

Your group must do the following:

1. Discuss among yourselves and agree upon the best place to land.
2. Circle this area on your map.
3. Provide the latitude and longitude of the selected landing site on the page.
4. Provide a one-paragraph explanation on why you agreed on this landing site. Remember to look around the possible landing area for potential hazards such as cliffs, impact craters, mountains, volcanoes, etc…
5. Answer the questions on this page.
6. Each group member must turn in this page with a written explanation and questions answered.

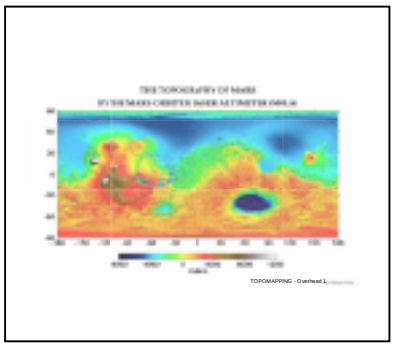
Questions:

1. Where is the highest and lowest region on your map? Give either a point or range in latitude and longitude.

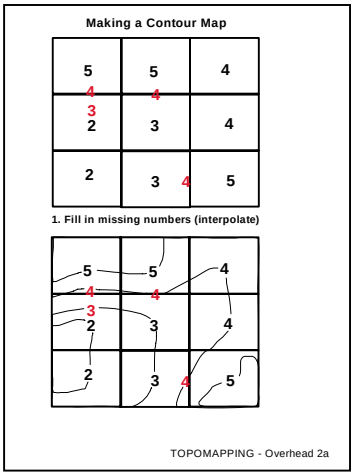
2. Scientists use altimetry data not only to see topography, but also to figure out in what direction and to what extent the surface of a planet slopes. In what direction is the surface sloping in your image? (Example: downward toward the northwest) How can you tell?

<u>Explanation for Chosen Landing Site:</u>

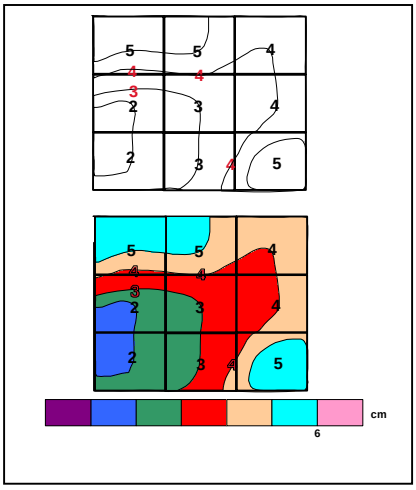
Overheads



Overhead 1. Topography of Mars (MOLA).



Overhead 2a. Making a contour map, part a.



Overhead 2b. Making a contour map, part b.