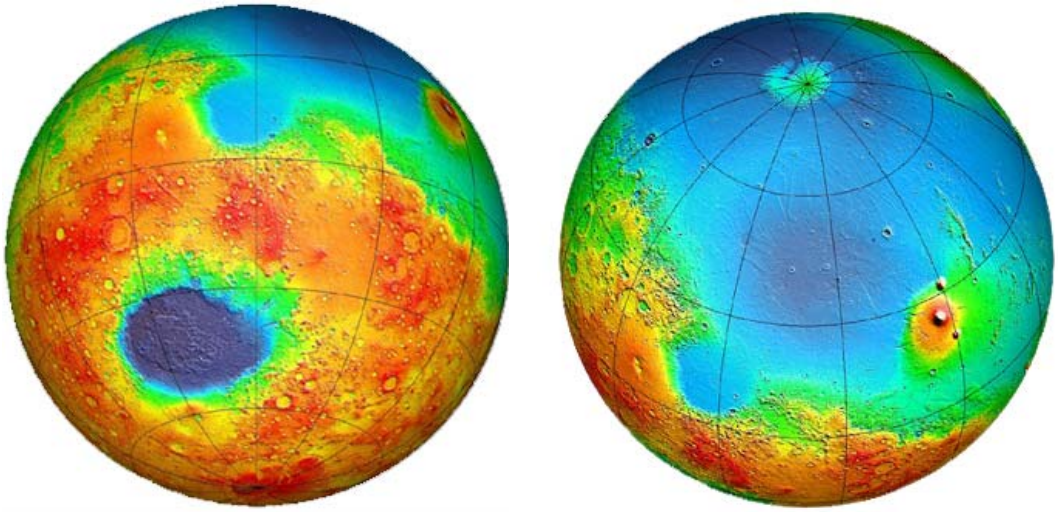
Highs and Lows
Floods and Flows

Planetary Mapping

Facilitator Guide



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Highs and Lows, Floods and Flows
Planetary Mapping

Overview

In this inquiry-based activity intended for grades 5 to 8, teams of students become familiar with the topography of Mars, it geologic features, and patterns of features using a color-coded topographic map. They discuss the geologic processes that have or are occurring and assign relative ages. Based on their observations and interests, they propose a landing site for their exploration team. The question sets, from 1 to 3, become increasingly challenging; if your students are familiar with maps, you may wish to skip question set 1 or review it briefly as a class.

Objectives

Students will:

- Gain general knowledge about how to read a topographic map
- Identify elevational features on Mars
- Identify geologic features and patterns on Mars and relate these to geologic processes
- Draw conclusions regarding the events and relative ages of geologic features

Time Requirement

60 minutes

National Science Content Standard G (grades 5-8)

Scientific Inquiry: Observe, describe, develop explanations, think critically about evidence, communicate.

Content Standard D, Earth and Space Science: Land forms are the result of a combination of constructive and destructive forces (volcanism, weathering and erosion, flowing water)

Content Standard F, Science in Personal and Social Perspectives: Natural hazards (volcanos, impacts)

Materials

- Mars Orbiter Laser Altimeter map: http://www.lpi.usra.edu/science/treiman/greatdesert/workshop/marsmaps1/marsmaps1_imgs/mola_color_2.jpg
- Writing utensil
- Highs and Lows, Floods and Flows Investigator Package

Introduction

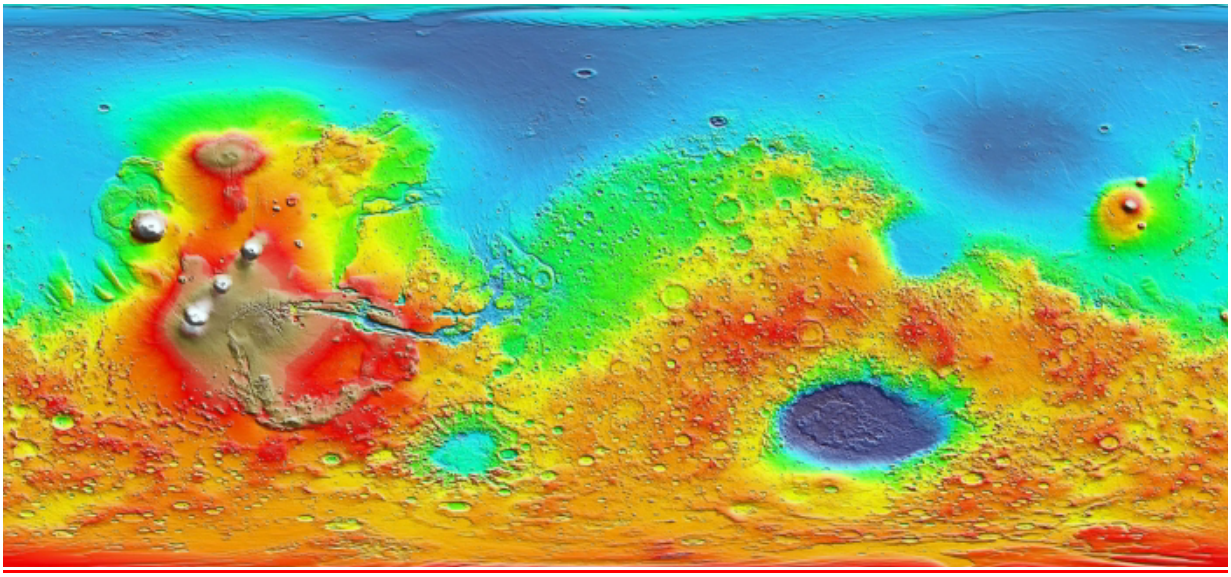
Planetary scientists can say a lot about a planet's history by looking at a map of its surface. They examine the features to understand the geologic activity that has occurred, look for patterns, determine the order in which events happened – and formulate questions for further exploration. They use maps to select locations on the planet's surface to investigate those questions. Maps are critical for identifying targets for rovers, human exploration, and future colonies.

1. **Ask each group to imagine that they are a team of planetary scientists** who want to understand the geologic history of a planet. Ultimately they will propose future landing sites for exploration that will help to answer *their* interesting scientific questions.

- What scientific question do they have?
- Where is the best place to on the planet to address this question?
- Where would the safest place be to land a rover or an astronaut to address this question?

2. **Invite each team to begin the challenge by carefully studying the picture below** (on their page 2) to determine what kind of picture it is and what features might be represented by the different colors.

- What particular type of picture do you think this is? **(a map)**
- What do you think is represented by the different colors? **(the answer to this question – elevation – will be discovered by students as they progress through the exercise)**



3. **Review the "Terms to Know"** and encourage their utilization throughout the activity.

Terms to Know

Topographic Map – a map that shows natural and human-made features of an area in a way that shows their relative positions and elevations. Topographic maps often show contour lines (lines of equal elevation).

MOLA Map – a color-coded topographic map of Mars' surface obtained from laser altimeter measurements taken by the Mars Orbiter Laser Altimeter 1997-2000.

Crater – large depressions in a planetary surface caused by impactors, such as asteroids or comets. Craters typically are circular in shape and have raised rims.

Channel - the bed where a natural stream of water (or lava) runs, or ran. Channels can be straight or sinuous.

Volcano – usually a large conical structure forming at a vent in the surface of a planet through which magma and gases erupt. The conical feature builds up from the erupted material.

Lava – molten rock that flows on the surface of a planet (magma is molten rock that is still inside the planet).

Early bombardment – a period early in the history of the Solar System during which asteroid impacts were very frequent. Very large craters were created on the planets at this time, caused by large impactors. While impacts still occur today, they are less frequent and smaller.

Fault – a break in a planet's surface, along which blocks of the surface move relative to one another.

4. **Distribute to each group one copy of the color-coded MOLA map that includes the title and map key.** Have them work together to answer the questions on the following pages.

   You may wish to review the answers to each Question Set before proceeding to the next.

Question Set 1
Observing Patterns

1. This is a map of which planet? **Mars**

2a. What do the colors on the map key signify? **Elevation**

2b. What physical features are represented by *all* topographic maps? **Size, shape, and elevation are shown on all topographic maps.**

3a. Where on this picture is north located? **Up, or at the top**

3b. What about south? **Down, or at the bottom**

4. Where do you think the equator is located? **Horizontally across the middle at 0° latitude**

5. Where do the red, orange & yellow colors tend to occur? **Most of the red, orange, and yellow colors tend to occur on the bottom, in the southern hemisphere**

6. What about the greens and blues? **Most of the greens and blues occur toward the top, in the northern hemisphere**

7. The tans and whites? **The tans and whites appear together**

8a. Which colors represent higher terrain? **The tans, whites, reds, and oranges are higher terrain**

8b. Lower regions? **The greens, blues, and purples represent lower regions.**

9. How do you know? **You can tell by reading the elevation key on the map you have been given.**

10. What patterns do you observe? **Answers will vary and may include:**

"Most" of the blues and greens are located in the northern hemisphere

Most of the reds, oranges and yellows are south of the equator

Yellows and greens are found along the length of what looks like a shoreline

The rough areas are almost exclusively reds, oranges, and yellows

All the white areas are grouped together in close proximity to one another

Question Set 2
Analysis & Synthesis

1. What "type" of map is this? **This is a topographic map; it provides elevation information** (more explicitly, this a Mercator projection, a rectangular map with lines of latitude and longitude intersecting at right angles, in which true compass directions are correct but the areas are distorted; features in the extreme north and south are stretched).

2. What color are the mountain tops? **White**

3a. Do any of the colors signify water? **No**

3b. If not, what does the color blue signify? **Lower elevations**

4. Refer to the "Terms to Know" and explain what feature is represented by the darkest blue area. **The darkest blue area is a large impact crater basin.**

5. What could have caused the *darkest* blue area to be in a location separate from the large *lighter* blue areas? **That is where an impactor landed, creating a depression even deeper than the naturally occurring lowlands.**

6. What indications of past or present flowing water do you observe? **(Channels from the highlands to the lowlands occur east of the mountains)** Use your writing utensil to mark the possible directions of the flows.

7. Which areas (colors) of the map look rough? **Most of the red, orange, and yellow areas look rough**

8a. What makes the area rough? **Lots of circular patterns of different sizes.**

8b. What do you think caused the roughness? **Referring to the "Terms to Know", students can conclude that the rough areas are heavily cratered from meteorite impacts.**

9a. How would you describe the surfaces downslope from the highest peaks (rough or smooth)? **Smooth** 9b. Do these surfaces have many craters on them? **No**

10. What might have caused the smoothness; why might this area not be cratered? **Answers will vary: Something smoothed it out. It was eroded. There were not as many impacts. Water smoothed it out. Lava flows smoothed it out. Wind smoothed it out.**

11a. What kind of geologic features are the highest mountains? **Volcanos**

11b. Why do you think that? **They are the right shape and have lava flows around them.**

12. What is the feature just to the east of the mountains that looks like an east-west gash in the surface of the planet? **A large fault** (Valles Marineris; this feature formed where the surface of Mars bows up a bit – probably because it sits over a hotspot. The surface bowed up, thinned, stretched and broke. The hotspot also is the source of magma for the volcanos)

Questions Set 3
Drawing Conclusions

1. How could smooth surfaces on Mars become rough? **From meteorite impacts**

2. How could rough surfaces on Mars have been smoothed out? **Answers will vary: from flowing water (erosion), being covered up, being filled in by flowing lava….**

3. There is a big difference in the character of the northern part of Mars and the southern part. What could have caused the northern terrain to become smooth? **Answers will vary: from flowing water (erosion), being covered up, being filled in by flowing lava, having a big ocean in the north….**

4. Which do you think is older, the red rough terrain or the lighter blue smooth terrain? **The red rough terrain**

5. What are your reasons? **The lowest (blue-colored) terrain has fewer craters. Something happened to fill them in.**

Students may need some help making this connection. Planetary geologists assume that any location on a planet has an equal chance of being hit by impactors. So they expect a planet to have an even distribution of impact craters.

When an area has few craters, they are suspicious that another event has occurred to smooth the surface, such as lava flowing across the surface, or erosion.

Old surfaces have lots of impact craters, young surfaces have few impact craters. Just like old faces have lots of wrinkles and young faces have few wrinkles. With time, a planet accumulates more and more impacts.

Imagine a sheet of mud in a rainstorm. Early in the rainstorm, when only a few drops have fallen, there will be only a few raindrop patterns in the mud. With time, as the storm continues, more and more raindrop imprints will left in the mud. The longer (older) a planet surface is, the more raindrop/impact craters it will have. After the storm, you have a mud sheet peppered with raindrop imprints; imagine taking a bowl of mud and pouring it across half of the sheet. In the area where the new mud was poured, the imprints will be filled in / smoothed over by a newer surface.

It is important to note that planetary scientists today are debating what caused the differences in the terrain of the northern and southern regions of Mars. There is no clear answer yet!

6. Which do you think is older, the *rough* red terrain or the *smooth* red terrain (around the mountains)? **The "rough" red terrain is older.**

7.What are your reasons? **The rough red terrain has more craters; the smooth red terrain is younger and has not been hit by as many impactors. The smooth terrain probably is formed by lava flows because they sit next to volcanos.**

To Summarize……

To Mars!

Decide as a team what scientific question you have about Mars. Based on your investigations, this could be a geologic question, but it could also be another question that can be answered by the scientific process.

_____

_____

_____

_____

To what location will you send the rover or astronaut to gather information that will address your question?

Latitude: _____

Longitude: _____

Why did you choose this site?

_____

_____

_____

The MOLA map you just used to determine your landing site was one of the same maps used by NASA scientists and engineers to determine the landing sites of Spirit and Opportunity in the recent MER Mission to Mars. Spirit landed in Gusev Crater, located at 14.57° South and 184.53° West. Opportunity landed on Meridiani Planum, located at 1.95°South and 5.53° West.

Based on your study of the MOLA topographic map of Mars, describe its topographic features and the geologic processes you think may have caused them. Based on your observations, describe how the red planet has changed through time.

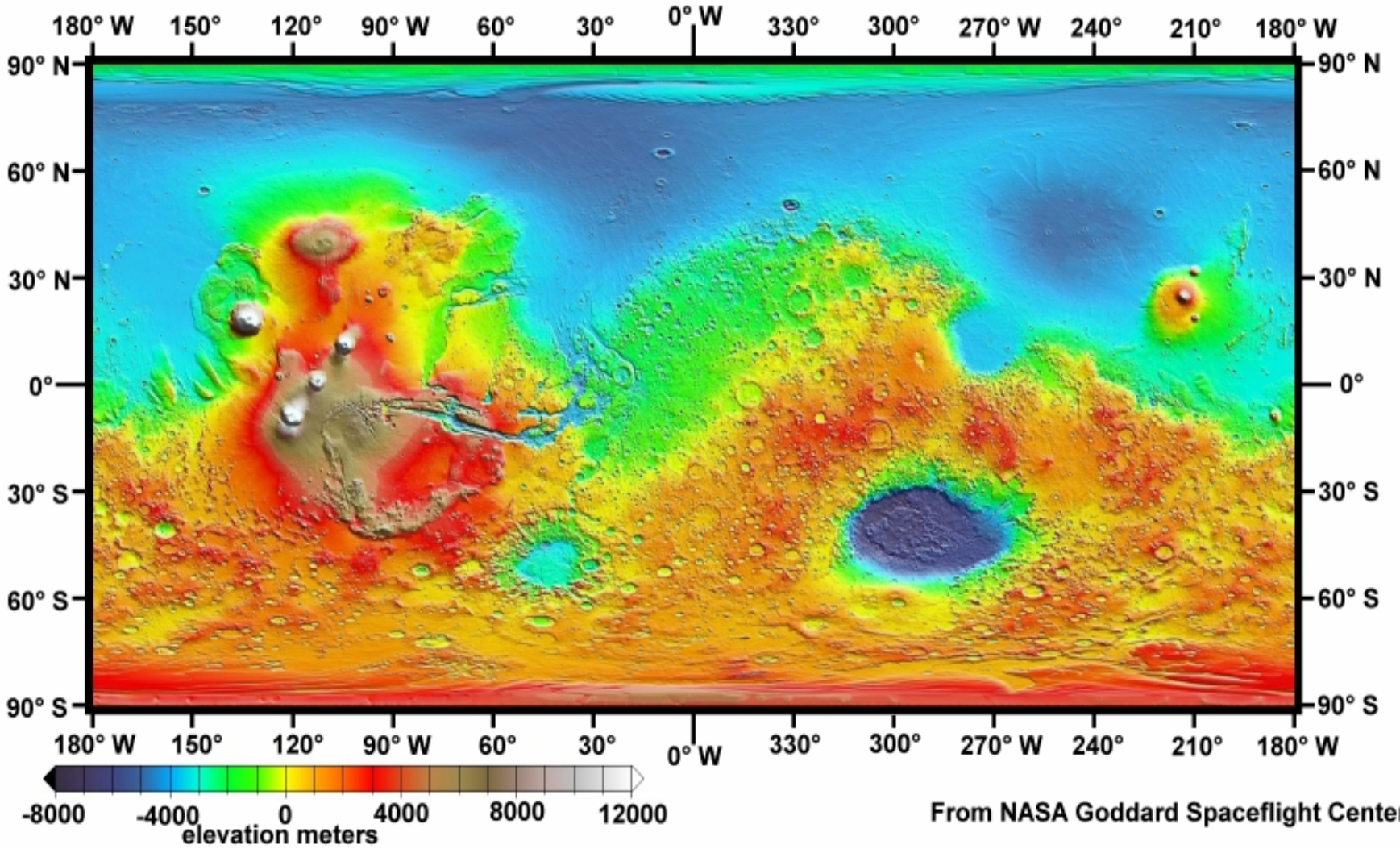
Answers will vary, but should include the following:

For topographic features: Volcanos (or volcanic mountains) / a much lower, smoother northern hemisphere with few craters / higher, rougher southern hemisphere with lots of craters / a large depression, or impact basin in the southern area / possibly a shoreline separating northern and southern areas / smooth areas downslope of the mountains / a large fault to the east of the mountainous area / channels cutting from the highlands to the lowlands to the east of the volcanos.

For geologic processes: Volcanism with large lava flows / cratering / flowing water carving channels, faulting

For evolution of the planet: heavily cratered by impacts / craters in low area were filled in or eroded / flowing water carved channels between high southern area and low northern area / volcanos erupted last; the lava has smoothed the topography around the volcanos.

Color-coded Elevations on Mars, MOLA Altimeter, MGS Mission



From NASA Goddard Spaceflight Center