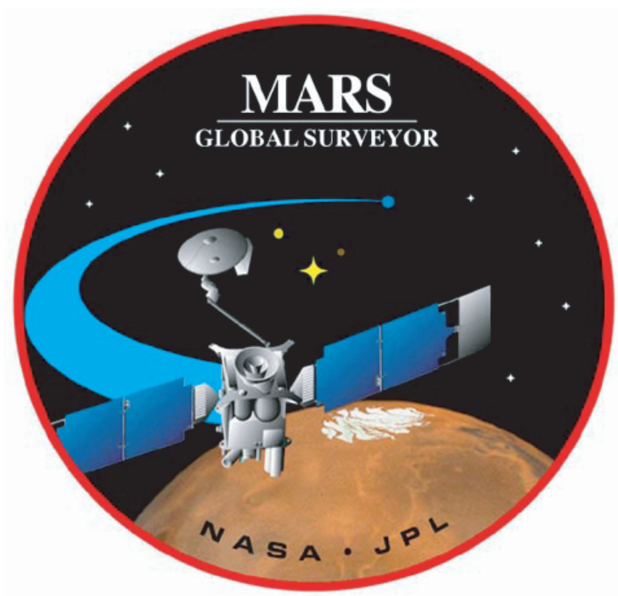
MAPPING THE SURFACE OF A PLANET

Teacher Guide



ARIZONA STATE UNIVERSITY

Mars Education Program
Jet Propulsion Laboratory
Arizona State University

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Mapping the Surface of a Planet

Written and Developed by:

Keith Watt, M.A., M.S.
Assistant Director
ASU Mars Education Program

Edited by:

Paige Valderrama, M.A.
Assistant Director
ASU Mars Education Program

Sheri Klug, M.S.
Director
ASU Mars Education Program

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MAPPING THE SURFACE - TEACHER GUIDE

Mapping the Surface of a Planet is intended to fit within your existing Earth science curriculum, rather than in addition to it. This Teacher Guide presents tips that you can use to make *Mapping the Surface* an engaging educational experience for your students. The background information presented on pages 1-6 is intended to be given to each student or student team. The three activities (one using data from each instrument on board *Mars Global Surveyor*) are best set up as stations through which student teams can rotate, but can also be used as a whole class activity. Each team should have a printed copy of all three activity sheets, but the image itself can be placed at the appropriate station. Of course, if resources permit, each team can be given a complete set of images. If students do have their own copies, it is suggested that you allow the students to circle features they have found in each image, writing notes about their observations directly on the image. Vocabulary words are printed in bold text throughout the background material. Definitions can and should be obtained from the context, rather than presented as simply a list of words. In this way the students not only learn the targeted vocabulary, they are also given the opportunity to practice comprehension skills.

Activity 1: Features Near Olympus Mons (MOC2-102)

1. *a) 7 km b) 12 km.* It is important that you stress the sense of scale in the images contained in each activity. Each is taken at very different resolutions (levels of detail), so actual sizes of the surface features shown will vary.
2. *Answer depends upon students. There is no right or wrong answer here.* The important issue is that they make a hypothesis, but then realize they do not have sufficient information to answer the question. This process is at the core of the scientific method.
3. *It is an impact crater. Shadow on right = lowered, shadow on left = raised.* You will need to demonstrate this using a bucket. Shine a light (flashlight, sunlight, etc.) at an angle across the top of the bucket. The side of the bucket nearest the light will be in shadow, while the opposite side will be lit. Turn the bucket upside down and you'll get the opposite result.
4. *The lava flows are older.* Because the winding, river-like feature cuts across the lava flows, the Principle of Cross-Cutting Relationships says that the lava flows must be older.
5. *This is an example of what to look for: "Olympus Mons erupted, sending massive amounts of lava flowing outward. River runoff (or lava from a later eruption) cut a canyon through the lava flow. Later runoff through the canyon carved the smaller channel. A meteor impacted in the area, causing a crater that partially covered the canyon and smaller river bed.* Different students will identify different features, but all should have something plausible. A quick tip: Some people find the canyon easier to visualize if the image is turned upside down!

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Activity 2: Albedo of the Tharsis Province

1. *a) 7% b) Dark c) 37% d) Light e) ~18-22%*. There are two important concepts in this question: first, can the students correctly interpret a visual scale, and second, do they undersand the concept of albedo. Albedo is nothing more than how bright or dark certain areas on the planet are, just like looking at a black and white television set. TES is somewhat unique in that it measures not only the "visual brightness", but also the "infrared brightness". Depending upon the level of your class, this could be the perfect time to introduce your students to the electromagnetic spectrum, if you have not done so already. Once you have explained the colors in the visual part of the spectrum, it's not too difficult for the students to visualize a color "redder than red, so red that that your eye can't see it".
2. *a) Pavonis Mons b) Arsia Mons.* This question is intended to provide an application of the concept of albedo, but also serves as an introduction to Martian geography. Remember that a place seems more "real" when you have a name for it!
3. *a) Northwest (This is given in the question.) b) Northwest c) The clouds are being blocked by the tall volcanoes. d) The winds on Mars in this region must have been blowing west to east when this image was taken.* The situation on Mars is similar to the "rain shadow" of mountain ranges on Earth. The winds are blowing the clouds against the mountains, so they all "congregate" on one side of the volcanoes. Most people don't think of Mars as having weather, but it does! In fact, Mars provides meteorologists on Earth with a simpler atmosphere they can study to improve their knowledge of Earth's atmosphere.
4. *a) Ice clouds b) The lower altitude of the canyon floor is cooler and often protected from the Sun, so clouds are more likely to form there.* The spacecraft *Lunar Prospector* found deposits of water ice on the surface of the Moon, hidden in craters that were sheltered from the Sun. Could we possibly find water ice in Valles Marineris?
5. *a) Bright b) The ice at the pole reflects the light very readily, making the surface appear bright.* Your students should be able to draw this conclusion by making an extension of their knowledge of the brightness of water-ice clouds, as discussed in the previous questions. Be sure to point out to them that the black spot directly at the pole is simply a region that Mars Global Surveyor was unable to map. We don't have any data there, so we don't have any colors. Mars Global Surveyor was in a nearly-polar orbit which enabled it to map almost all of the surface of Mars. Had it been in an exactly polar orbit, it would have been able to fill in the black spot in this image.

Activity 3: Topography of the Tharsis Province

1. *a) 30 degrees b) 40 degrees.* Here we are using latitude and longitude rather than using kilometers directly. Mars uses the same latitude and longitude system we use on Earth, so this is a good time reinforce that concept. Because the image is centered on the equator, the distance represented by one degree of both latitude and longitude is approximately the same. For a more advanced class, you can point out that this is not true everywhere on a globe because the lines of longitude converge at the North Pole!

2. *a) about 12,000 m for all three volcanoes b) ~8 degrees, ~5 degees, and ~6 degrees, respectively. c) ~472 km, ~295 km, and ~354 km, respectively.* This question has the dual purpose of allowing you to reinforce scale and multiplication tasks and of getting a sense of just how big these volcanoes are. Putting them in perspective to known distances ("about the same size as Arizona") will be very helpful. Note: Student answers will vary somewhat.

3. *They must be shield-like volcanoes because the bases are so big and the slopes are so low.* Remind your students that the background material states that hotter lava flows a further distance and shield volcanoes have the hottest lava of all five volcano types, so the lava flows the furthest and creates the largest bases and the lowest slopes.

4. *Basalt. Basaltic lava is hotter and therefore flows further than silica-rich lava.* Now we have a good idea what the material that makes up the lava flow is. Point out that geology is a like detective story - from small clues, we get big answers.

5. *An example: "The Tharsis Montes volcanoes formed and then erupted, sending lava flowing out onto the surrounding plain. Two smaller volcanoes erupted, adding more lava to the initial flow. Finally, some object impacted the surface, creating a crater on the lava flow."* Again, student responses will vary depending on which features they chose to rank. Note that the smaller volcano could have formed after the impact crater, but because we assume the volcanism all occurred at about the same time, we assume that the smaller volcano formed not too long after the Tharsis Montes. Again, you are grading the students' thinking and reasoning skills -- if they can support their answers, they have achieved the educational objective.

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Features Near Olympus Mons (MOC2-102) - Data Log

Feature	Grid Coordinates	Age Rank	Notes
Main Lava Flow	0 km, 0 km to 5.0 km, 5.0 km	1	All features cut across the flow.
Canyon	0 km, 12.0 km to 7.0 km, 0 km	2	Cuts across lava flow, but has other features on it.
Long Channel	4.5 km, 6.0 km to 4.5 km, 8.0 km	3	Cuts across plain and canyon.
Short Channel	3.0 km, 7.5 km to 4.5 km, 8.0 km	4	Cuts across long channel
Impact Crater	4.5 km, 4.75 km	5	Clearly defined edges, no erosion, so must be recent.
Eroded Crater	4.0 km, 4.25 km	6	Extemely eroded, so must be older.

Topography of the Tharsis Montes Region - Data Log

Feature	Grid Coordinates	Age Rank	Height
Volcano	-104.5, +11 deg	1	12,000 m
Volcano	-113, +0.5 deg	1	12,000 m
Volcano	-120.5, -9.5 deg	1	12,000 m
Lava Flow	-123, +10 deg to -116.5, +7 deg	2	5,000 m
Volcano	-124.0, +2.5 deg	3	5,000 m
Impact Crater	-113, +8.5 deg	4	3,000 m rim, 0 m floor

Appendix 1: *National Science Education Standards*

Mapping the Surface of a Planet is not just a fun and motivating activity for your students, it also satisfies many of the standards laid down by the National Research Council in their publication *National Science Education Standards* (1996). In this appendix we identify the specific *Standards* which are met by this activity. The relevant section titles are given in parenthesis.

Content Standards:

CONTENT STANDARD A: As a result of their activities, all students should develop the abilities necessary to do scientific inquiry:

1. Identify questions that can be answered through scientific investigations. (Activity 1, Activity 2, Activity 3)
2. Conduct a scientific investigation. (Act.1, Act.2, Act.3)
3. Use appropriate tools to analyze and interpret data. (Act.1, Act.2, Act.3).
4. Develop descriptions and explanations using evidence. (Act.1, Act.2, Act.3)
5. Think critically and logically to make the relationships between evidence and explanations. (Act.1, Act.2, Act.3)
6. Recognize and analyze alternative explanations. (Act.1, Act.2, Act.3)
7. Communicate scientific procedures and explanations. (Act.1, Act.2, Act.3)
8. Use mathematics in all aspects of scientific inquiry. (Act.1, Act.3)

CONTENT STANDARD D: As a result of their activities, all students should develop an understanding of:

1. Structure of the Earth system (Volcanoes, Stratification, River Beds, Act.1, Act.2, Act.3),
2. Earth's history (Impact Craters, Stratification, Principle of Superposition, Principle of Cross-Cutting Relationships, Principle of Horizontal Bedding, Act.1, Act.2, Act.3),
3. Earth in the Solar System (Identifying Surface Features).

CONTENT STANDARD G: As a result of their activities, all students should develop an understanding of:

1. The nature of science (Principle of Superposition, Principle of Cross-Cutting Relationships, Principle of Horizontal Bedding, Act.1, Act.2, Act.3).

Appendix 1: *National Science Education Standards* (cont.)

In addition to content standards, the *National Science Education Standards* roadmap also lays out teaching standards to guide educators in the best practices for the teaching of science. *Mapping the Surface of a Planet* models these teaching standards and serves as a vehicle for their implementation. The specific *Standards* for which the unit is especially well-suited are outlined below.

Teaching Standards:

TEACHING STANDARD A: Teachers of science plan an inquiry-based science program for their students.

1. Develop a framework of year-long and short-term goals for students.
2. Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.

TEACHING STANDARD B: Teachers of science guide and facilitate learning.

1. Focus and support inquiries while interacting with students.
2. Orchestrate discourse among students about scientific ideas.
3. Challenge students to accept and share responsibility for their own learning.
4. Recognize and respond to student diversity and encourage all students to participate fully in science learning.
5. Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.

TEACHING STANDARD C: Teachers of science engage in ongoing assessment of their teaching and of student learning.

1. Use multiple methods and systematically gather data about student understanding and ability.

TEACHING STANDARD D: Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.

1. Structure the time available so that students are able to engage in extended investigations.
2. Create a setting for student work that is flexible and supportive of science inquiry.
3. Ensure a safe working environment.

Appendix 1: *National Science Education Standards* (cont.)

4. Make the available science tools, materials, media, and technological resources accessible to students.
5. Engage students in designing the learning environment.

TEACHING STANDARD E: Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

1. Display and demand respect for the diverse ideas, skills, and experiences of all students.
2. Enable students to have a significant voice in decisions about the content and context of their work and require students to take responsiblity for the learning of all members of the community.
3. Nurture collaboration among students.
4. Structure and facilitate ongoing formal and informal discussion based on shared understanding of rules of scientific discourse.
5. Model and emphasize the skills, attitudes, and values of scientific inquiry.

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	Nature of Science	Earth in the Solar System	Earth history	Structure of Earth System	Mathematics in science	Communication	Analyze alternative explanations	Relate evidence and explanations	Develop explanations using evidence	Use tools and analyze data	Conduct a scientific Investigation	Identify Questions
Background												
Identifying Surface Features		●										
Impact Craters			●									
Volcanoes				●								
Stratification			●	●								
River Beds				●								
Principle of Superposition	●		●									
Principle of Cross-cutting Relationships	●		●									
Principle of Horizonal Bedding	●		●									
Activities												
Activity 1	●		●	●	●	●	●	●	●	●	●	●
Activity 2	●		●	●		●	●	●	●	●	●	●
Activity 3	●		●	●	●	●	●	●	●	●	●	●