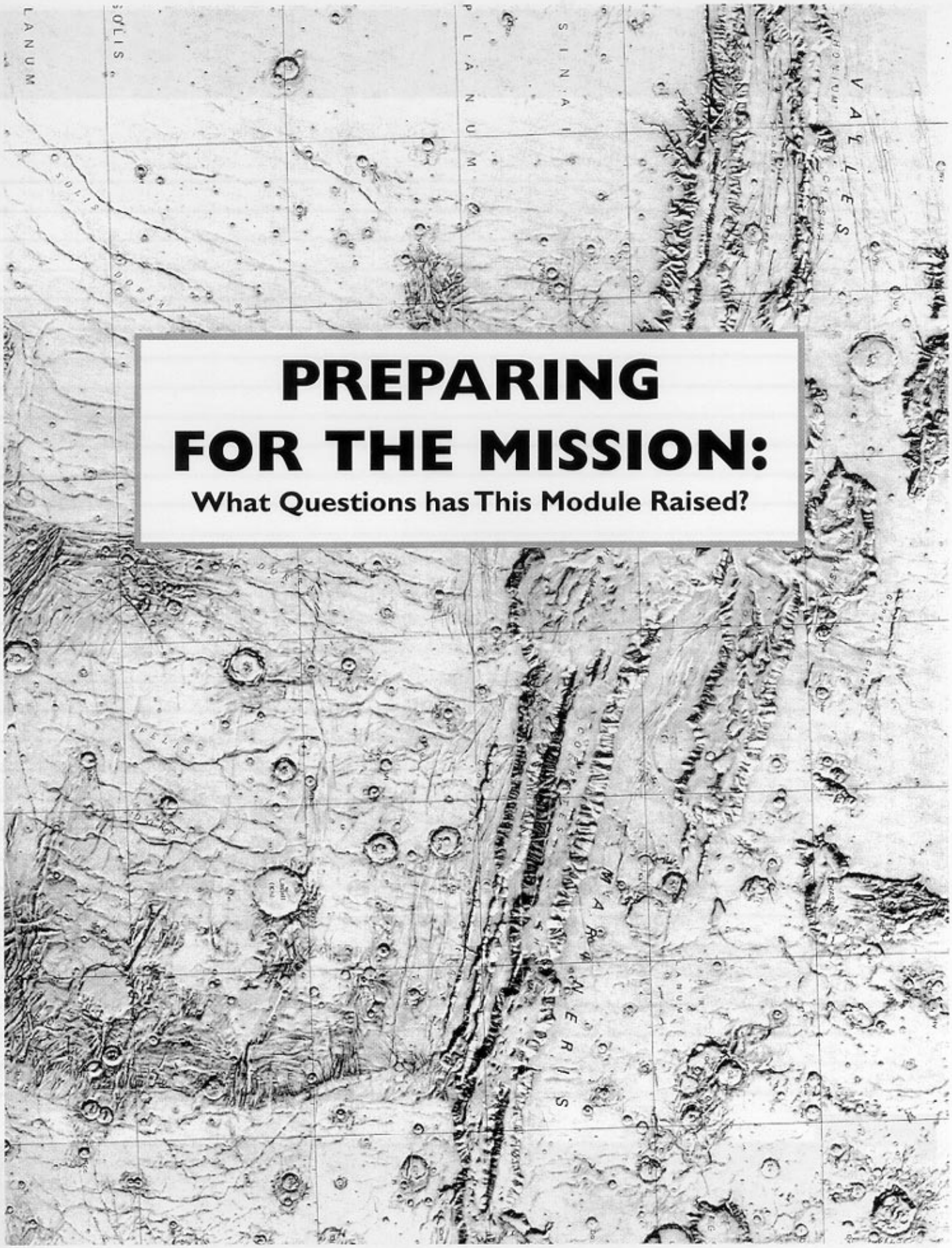


PREPARING FOR THE MISSION:

What Questions has This Module Raised?

NOTES

AT A GLANCE

Overview

To develop an on-going connection with the upcoming missions, students reflect on their experiences in the module, articulate their questions and pinpoint specific information they would like to obtain. They then read about the instruments on the *Mars Global Surveyor* and relate their questions to the information its instruments will provide. Finally, students create a calendar for the missions and consider how, in the future, they can access information returned by the probes.

Content Goals

- The *Mars Global Surveyor* has specific mission objectives and instruments to achieve those objectives.
- The mission objectives arise out of questions people have about Mars, and students are fully capable of generating questions worthy of future study.
- The *Mars Global Surveyor* mission has a specific timetable, and students can follow the progress of the mission in a number of ways.

Skill Goals

- *Identifying* questions that really interest students.
- *Devising* a plan to answer those questions.

Possible Misconceptions

- Three-meter resolution is not very good.
  Ask: How far away can you discern a three-meter object? How does this compare to the MGS orbit 400 km (250 mi) above the surface of Mars?
- All space probes have the same basic design and instruments.
  Ask: Do you think Voyager, Magellan or Galileo had any of these instruments?
- Robotic space exploration is inferior to manned space travel.
  Ask: What would have to be changed in order to have a human collect this information?
- Space missions are sent up all the time.
  Ask: How often are space missions launched? What prevents NASA from launching as many missions as it wants? How long can scientists find interesting information in a set of images? Do you think that people assume that there are lots of missions because we see a lot of pictures from space these days?

Materials

Calendar of the missions, length of paper to make timeline.

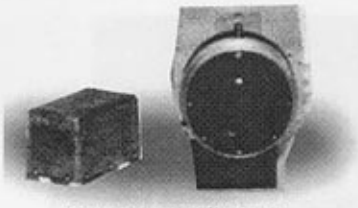
Preparation

Obtain a computer with Web access to visit some of the mission-related sites.

Time

1 class period

BACKGROUND

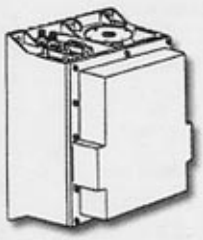


Magnetometer/Electron Reflectometer

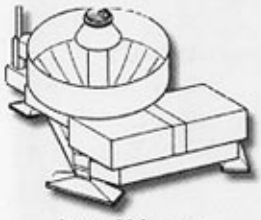
At the end of 1996, NASA launched two missions to Mars, the *Mars Pathfinder* and the *Mars Global Surveyor (MGS)* (Fig. 5.1). Of these two missions, the *MGS* will shed the most light on the topics covered in this module. *MGS* will study Mars from an orbit 400 km (250 mi) above the surface. It was launched in November of 1996, will arrive in September of 1997, and will begin a two-year mapping mission of Mars in March of 1998. *MGS* has three cameras with resolutions as high as 3 m (10 ft). This compares to the highest resolution images from *Viking* of 20 m (65 ft).

Other *MGS* instruments include:

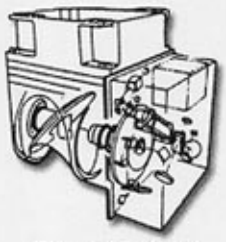
- a magnetometer/electron reflectometer to study the planet's magnetic field;
- a radio system to study Mars's gravity field and subsurface mass distribution;
- a laser altimeter to study the planet's surface topography and its overall shape;
- a thermal emission spectrometer to study the heat coming from the surface and atmosphere. This information will enable scientists to create weather maps and identify the size and composition of surface materials.



Radio Science Investigation



Laser Altimeter



Thermal Emission Spectrometer

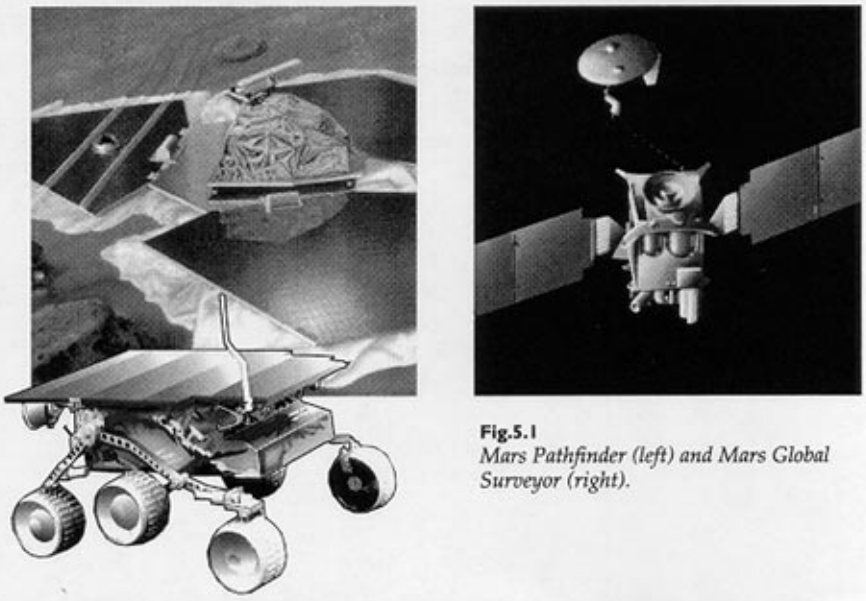


Fig.5.1
Mars Pathfinder (left) and Mars Global Surveyor (right).

PROCEDURE

1. Have students reflect on their modeling, image analysis and experimental work and generate a list of questions. What have they wondered about during the module? What struck them as particularly interesting? What additional information do they wish they had? Which features they would like to see in more detail? Why? Questions might include: Were there lakes at the bottom of Valles Marineris? Are slumping, sapping and subsidence still occurring? Are the canyons getting wider? Since the canyon walls expose up to 10 km of the crust, is there any evidence of life to be found in the cliff walls?

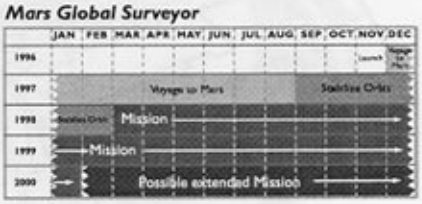
2. Have students read about the instruments on the *MGS*. *(See both the material included with this activity and the descriptions in the Getting Started module.)*

3. Review the *MGS* mission, noting that *MGS* will orbit Mars and collect data for at least a full Martian year (two Earth years). Review the instruments that especially pertain to studying Valles Marineris: the cameras, Thermal Emission Spectrometer *(chemical composition)* and Laser Altimeter *(elevation)*. Which of their questions can each instrument help answer? What instruments would they like to see on a future mission? Could they imagine themselves designing or operating such an instrument?
   Planetary missions take years of preparation. Some of the scientists and engineers have been preparing for the Mars Global Surveyor for over ten years.

4. Show students the calendar for the mission, including the fact that *MGS* will need to stabilize its orbit. Ask them:
   - where they might be at these times;
   - how might they access information from the instruments or about the mission.

   Newspapers, magazines, the Web, television, radio, friends.

Mars Global Surveyor



5. Have each student devise a plan that outlines how he or she might obtain answers to his or her questions.

6. Explain that approximately every week a new set of images from *MGS* will be posted on the World Wide Web. Your students will be able to use computers at school or at home to access these images. The released images will include close-up images of Valles Marineris as well as many other parts of Mars. Once this release of images begins, your students can build on the questions and excitement these images raise and extend their studies of Mars. Ultimately, students may even be able to request that images be taken of a site they are interested in studying. To learn more about the Mars Exploration Program, visit the following Web sites:

Mars Global Surveyor:	http://mgs-www.jpl.nasa.gov/
Mars Pathfinder:	http://mpfwww.jpl.nasa.gov
Jet Propulsion Laboratory	http://www.jpl.nasa.gov/

7. Put a timeline on the wall showing the months from now until June, 1998. Mark the events listed on the calendar to follow the progress of the missions.

INSTRUMENTS ON MARS GLOBAL SURVEYOR THAT PERTAIN TO THIS MODULE

based on an article by Mike Malin, Principal Investigator on the MGS camera

In November 1996, NASA launched the *Mars Global Surveyor* (*MGS*). After a ten-month cruise, the spacecraft will enter an elliptical orbit around Mars. For about six months thereafter, it will gently dip into the upper portions of the Martian atmosphere, using atmospheric drag to slowly shrink its orbit. In mid-March of 1998, it will begin its two-year mapping mission 400 km (250 mi) above the Martian surface.

Orbital Cameras

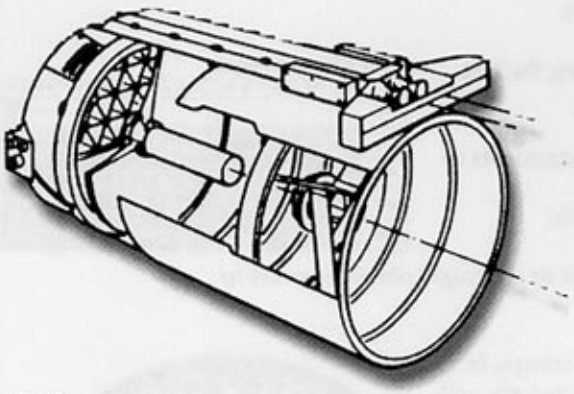


Fig. 1
A camera from the Mars Global Surveyor mission.

Particularly relevant to the study of Valles Marineris are the three cameras. *MGS* has two low-resolution cameras capable of recognizing features as small as 500 m (about 1,600 ft) across and one narrow-angle camera able to see things as small as 3 m (10 ft) across (Fig. 1). The low resolution cameras will make daily maps enabling scientists to see things such as surface features and dust and ice clouds. The narrow-angle camera, which can see boulders the size of cars, will be used to search for traces of beaches and glaciers, the effects of water seeping from canyon walls, and layers in polar deposits that may indicate climate changes. It will also look for the two *Viking* landers and the *Pathfinder* lander. If successful, these pictures will finally tie together the view from the ground and that seen from orbit. In contrast, the cameras on the *Viking* orbiter photographed only about 15% of Mars with a resolution of 100 m (305 ft), and only two tenths of one percent of the Martian surface was mapped in sufficient detail to show objects measuring 20 m (65 ft) in diameter.

Laser Altimeter

Also relevant to the study of Valles Marineris are two other instruments on the *MGS* (there are a total of five instruments on the *MGS*). The laser altimeter (Fig. 2) will tell scientists a great deal about the topography of Mars. Among other things, the altimeter will measure the:

- depths of craters;
- heights of volcanoes;
- steepness of the cliffs;
- slopes of water-carved canyons.

It will also be used in conjunction with other instruments to help determine the global shape of Mars and the thickness and strength of the crust.

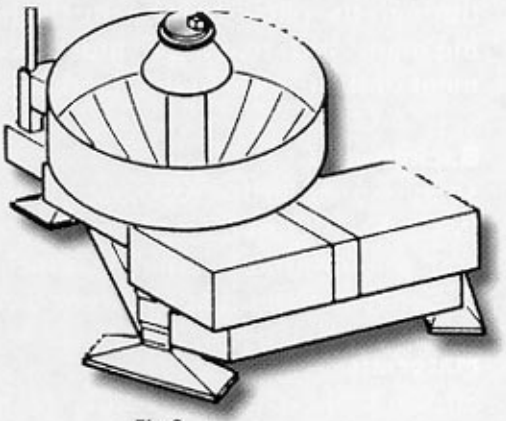


Fig. 2
The Laser Altimeter from the Mars Global Surveyor mission.

Thermal Emission Spectrometer

The Thermal Emission Spectrometer (TES) (Fig. 3) measures the amount of heat coming from the surface and atmosphere at many different wavelengths. TES will determine:

- atmospheric temperature and pressure at several different altitudes;
- the concentration of dust, both on the surface and spread throughout the atmosphere;
- the size of particles on the surface, from dust grains to bedrock, by comparing the temperature during the day with that observed at night (the same effect that causes beach sand to be very hot during the day and to be cool at night). The sizes of particles on the surface can help scientists tell how the particles were moved (e.g., by wind, water or other processes);
- what the Martian rocks, sand and dust are made of, and in what proportions. TES will be able to discriminate volcanic rocks similar to those found in Hawaii *(basaltic)* from rocks and ash similar to those erupted by Mount Saint Helens *(rhyolitic)*. It will search for minerals left behind from when possible lakes or other bodies of water dried up, and for minerals that formed when the atmosphere was potentially thicker and wetter than it is today.

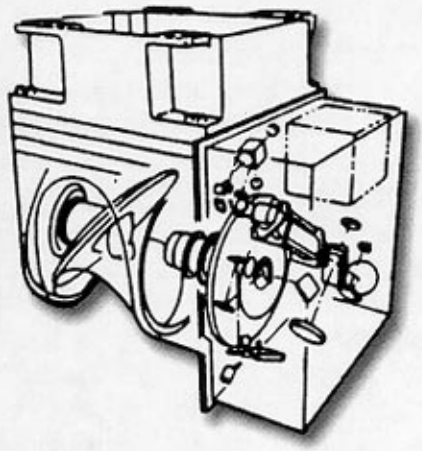


Fig. 3
The Thermal Emission Spectrometer from the Mars Global Surveyor mission.

Extension Activity: How Does MGS's Laser Altimeter Work?

Overview

To model how a laser altimeter profiles a landscape, students use objects to create a "landscape" in a container, cover the container with paper and then poke a skewer through the paper to measure the height of the object directly underneath. By taking many such readings, students determine the size, shape, height and arrangement of the objects in the "landscape."

Background

To measure Martian topography, *MGS* will carry the Mars Orbiting Laser Altimeter (MOLA). MOLA uses pulses of laser light to measure the distance from the spacecraft to the surface. Analogies include bat's sonar and ultra sound measurements. A planet's topography is determined by assembling sequential scan paths.

Materials

Stream table, container, bamboo skewer, ruler, graph paper, rubber band, and assorted objects.

Brief Description

1. To introduce students to reconstructing an object from many cross-sections, cut a green pepper longitudinally into two halves (i.e., "valleys"). Slice one of the halves crosswise into thin sections to represent a cross-sectioned valley. Each section represents one scan path. Have students reconstruct the "valley" from the "scan paths." Compare the re-assembled "valley" to the uncut "valley."

2. To introduce students to the idea of a scan path, create a channel in a stream table. Set a ruler across the tray and use a skewer to measure the height of the sand at one-cm intervals across the tray. Transfer these measurements to graph paper and construct a profile of this scan path. Move the ruler to a new location along the tray and repeat.

3. To have students model MOLA, have them secure objects to the bottom of a deli or cottage cheese container. Cover the mouth of the container with graph paper and secure it with a rubber band. Trade containers with another group. Using the grid as a guide, poke bamboo skewers, pencils or chop sticks through the paper to measure the contours of the objects below. Record the depth of each "sounding". Sketch profiles of the object's heights along various scan paths, their shapes, and the way they are arranged in the container. Uncover the carton to see how closely the sketches reflect the actual situation.

4. This may be a good time to lead in to the study of topographic maps. Have students make profiles of a given line they draw across a topographic map.

MATERIALS USED IN THE GRAND CANYON OF MARS MODULE

- **1 Teacher Handbook and student image sets**
  (one set per two students recommended)

  Mars Exploration Education and
  Public Outreach Program
  Jet Propulsion Laboratory
  4800 Oak Grove Drive
  Pasadena, CA 91109
  (818) 354-6111

- **Two Faces of Mars poster, Item # 1338, $15.00**
  Spaceshots
  33950 Barnby Rd.
  Acton, CA 93510
  (800) 272-2779 (phone)
  (805) 268-1653 (fax)

- **An Explorer's Guide to Mars poster, Item # 505, $6.00**
  The Planetary Society
  65 North Catalina Avenue
  Pasadena, CA 91106-2301
  (818) 793-1675 (phone)
  (800) 966-7827 (fax)

- **Grand Canyon of Mars Three-Dimensional Model, $27.50**
  Kristal Corporation
  5355 Louie Lane
  Reno, NV 89511
  (702) 824-5000

Maps and Photomosaics Used for the Grand Canyon of Mars Image Set

Map of Olympus Mons to Ares Vallis	I-1618 (1:15,000,000)
Topographic Map of Mars	I-2160 (1:15,000,000)
Map of Noctis Labyrinthus	I-1252 (1:5,000,000)
Map of central Valles Marineris	I-1253 (1:5,000,000)
Map of central Valles Marineris	I-1295 (1:2,000,000)
Topographic map of central Valles Marineris	I-1712 (1:2,000,000)
Photomosaic of landslides and grabens	I-1591 (1:500,000)
Photomosaic of pit chains and slumping	I-1590 (1:500,000)
Photomosaic of slumping and canyon floor	I-1590 (1:500,000)
Close-up of Tithonium and Ius Chasmas	I-1294 (1:500,000)
Adjoining photomosaics of Valles Marineris	I-1206, I-1207, I-1208, I-1184, I-1381 (1:2,000,000)

ADDITONAL RESOURCES FOR EDUCATORS INTERESTED IN MARS

Posters

Mars Pathfinder and *Mars Global Surveyor*, (while supplies last)

Mars Exploration Education and
Public Outreach Program
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-6111

Video

Mars Pathfinder, (while supplies last)

Mars Exploration Education and
Public Outreach Program, see above address.

CD-ROMs

Mars Navigator Interactive Multimedia CD-ROM, describes JPL's *Mars Global Surveyor* and *Mars Pathfinder* missions (while supplies last)

Mars Exploration Education and Public Outreach Program, see above address.

The Mars Educational Multimedia CD-ROM, provides a Mars atlas, Mars-based lesson plans, descriptive information about Mars, image processing software to extract information from the images in the Mars atlas and from new images acquired by future orbiter and lander missions.

The Center for Mars Exploration,
Mail Stop 245-1
NASA Ames Space Science Division
Moffett Field, CA 94035-1000
(415) 604-4217
Recommended ordering procedure:
http://cmex-www.arc.nasa.gov

Web Sites

Mars Global Surveyor: http://mgs-www.jpl.nasa.gov/

Mars Pathfinder: http://mpfwww.jpl.nasa.gov

Jet Propulsion Laboratory: http://www.jpl.nasa.gov/

Center for Mars Exploration:
http://cmex-www.arc.nasa.gov/

The Planetary Society: http://planetary.org/tps/

Arizona Mars K-12 Education Program
http://esther.la.asu.edu/asu_tes/

Periodicals

The Planetary Report

The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106-2301
(818) 793-5100 (phone)
(818) 793-5528 (fax)

Mars Underground News

The Planetary Society, see above address

Recommended Maps and Photomosaics of Selected Martian Features,

General:

Map of Olympus Mons to Ares Vallis	I-1618
Map of Eastern Valles Marineris to Ares Vallis	I-1448
Topographic Map of Mars (1:25,000,000) (1 map)	I-961
Topographic Map of Mars (1:15,000,000) (3 maps)	I-2160

Volcanoes:

Photomosaic of Olympus Mons	I-1379
Map and photomosaic of Tharsis volcanoes	I-1922

Canyons:

Map of Central Valles Marineris	I-1253
Photomosaic of entire Valles Marineris	I-1206, I-1207,I-1208, I-1184, I-1381

Floods

Photomosaic of channels and eroded landforms	I-1652
Photomosaic Dromore crater with breached ridge	I-1068

Pathfinder

Map of Ares Vallis	I-1551
Photomosaic of the flood channels near landing site	I-1343
Close-up photomosaic of landing site	I-1345 & I- 2311

($4.00, 3-4-week turn around)
United States Geologic Survey
Box 25286
Federal Center, Building 810
Denver, CO 80225
(800) 435-7627

NOTES

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These curriculum materials were developed through a sub-contract to TERC, Inc., a non-profit educational research and development company. The materials have been field-tested by teachers and reviewed by scientists. New versions of the materials will be released periodically, incorporating new discoveries about Mars and improvements based on teacher feedback.

For information about materials or the Mars Exploration Education Program please contact:

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Module Title	Getting Started	Grand Canyon of Mars	Pathfinder Landing Site	Volcanoes	Mars Pathfinder	Mars Global Surveyor
TEACHER MATERIALS	Teacher's Guide	Teacher Handbook	Teacher Handbook	tba	tba	tba
STUDENT MATERIALS	Student Guidebook	Grand Canyon of Mars Image Set	Pathfinder Landing Site Image Set	tba	tba	tba