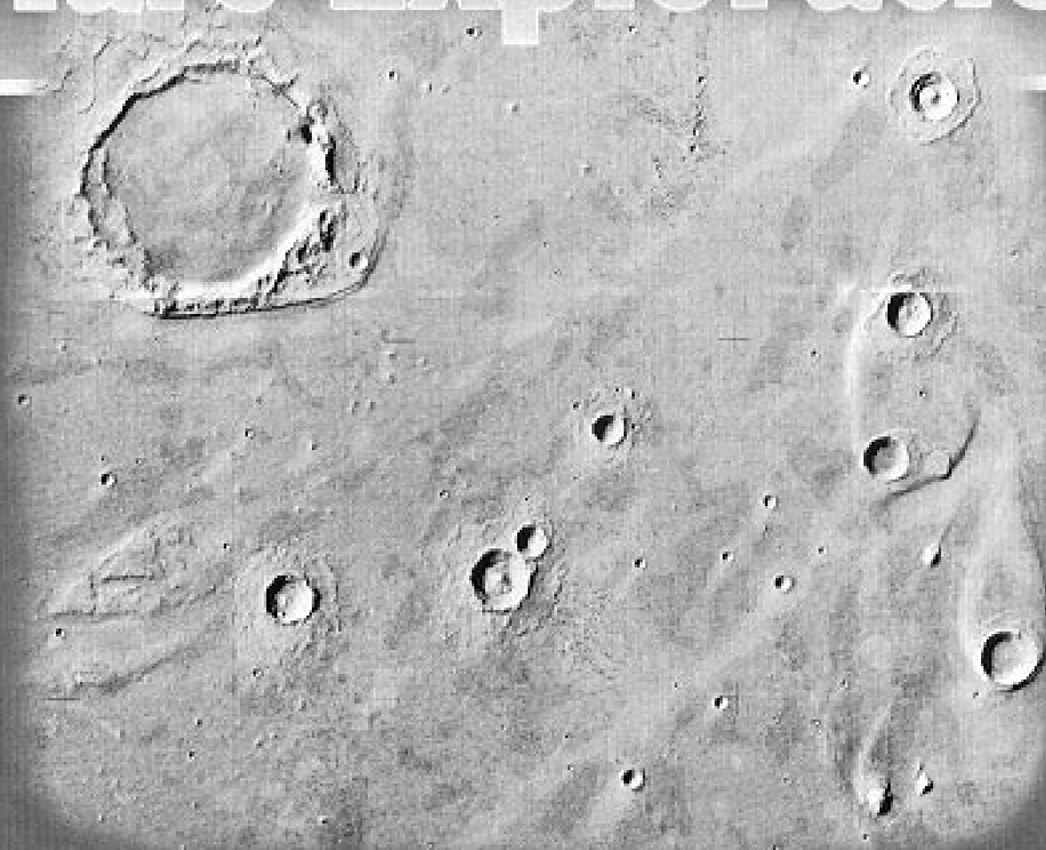
MARS EDUCATION PROGRAM

Mars Exploration



The Great Martian Floods and Pathfinder Landing Site

Teacher Handbook

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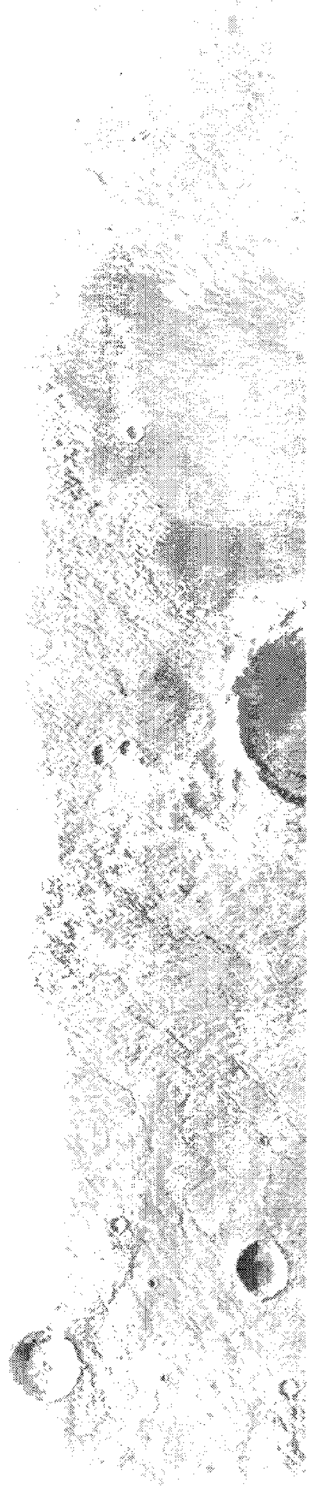


INTRODUCTION

Mars is one of the most interesting planets for classroom study. Mars is roughly half the diameter of Earth, but, surprisingly, its surface is almost the same size as all Earth's land areas combined. And just as Earth's surface is altered by a tremendous variety of processes, the same is true for Mars. However, the volcanoes, canyons, fluvial features and dust storms on Mars are on an immense scale; many are the largest observed in the solar system. Many of these features lend themselves well to classroom study because:

- geologic processes have occurred at a mammoth scale on Mars, and the landforms associated with these processes are huge – many are the biggest examples found in the solar system;

- the surface features are easy to see due to a lack of oceans, plants and thick clouds;

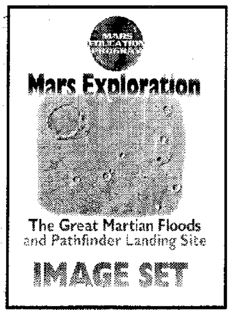
- while Mars has its own unique way of manifesting each process, there are distinct parallels with the way these processes work on Earth, so students can learn both Earth science and comparative planetology.

  Consequently, Mars serves as a powerful vehicle to teach technology and physical, life and earth sciences in an integrated, relevant way. In addition, Mars exploration is at its beginning and much more is to be learned about Martian history than is presently known. This provides students a unique opportunity to debate the alternate hypotheses and to refine their own ideas based on the images and data returned by the upcoming missions to Mars.

Why Teach This Module?

Ares Vallis illustrates one of the most interesting chapters in Martian history, the great floods. The module uses experimentation, image analysis and modeling to examine some evidence relating to the floods and puts the selection of the *Pathfinder* landing site in context. Questions students will consider include: Are the channels really flood channels? What fluid is responsible for the flood channels and where did it come from? Was the past climate of Mars considerably different? Will scientists actually find the diverse assortment of rocks and sediments they expect to find at the *Pathfinder* landing site? In addition, because the formation of certain features is often poorly understood, Mars poses some challenging riddles. The competing explanations within the scientific community and the gaps in the existing evidence leave plenty of room for students to develop their own hypotheses and amass evidence to support their ideas. Evidence can come from the modeling, image analysis and experimentation students do in this module. By the end of the module, students will understand how the features in Ares Vallis support the idea that there were mammoth floods on Mars and how *Pathfinder* intends to exploit such a history. In addition, they will better appreciate the reasons for planetary exploration and the kinds of questions it can help us answer.

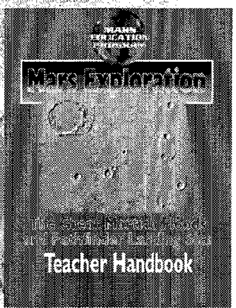
ORGANIZATION OF THE MODULE



Student Materials

The image set serves as the student material for this module. Ideally, each student should have his or her own set, the way they are assigned text books. The Teacher Handbook supplies reproducible student sheets for activities requiring such materials. Since there are no daily student sheets, students should use their Mars journals to keep track of the sequence of activities and to record the development of their thinking. The following format would enable students to provide themselves daily continuity:

- Activity title and a general description of the activity.
- A simple sketch of the activity setup.
- A table containing any data collected.
- A few conclusions.



Description of the Teacher Handbook

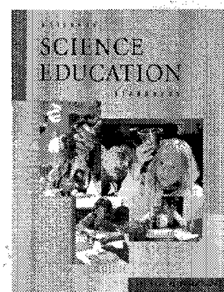
To provide both flexibility in terms of instruction and structure in terms of conceptual and pedagogical flow, the module has been written as a Teacher Handbook.
This handbook:

- has an overview page summarizing the activity, content and skills goals, possible misconceptions, materials, and time requirements;
- provides pertinent background information about the topic under investigation;
- describes each activity in a step-by-step fashion;
- alerts you to the key learning points in each activity;
- uses an "Applying the Model to Mars" section to provide context for student work;
- provides teaching hints such as where to look in the images to find examples that illustrate the learning points;
- offers classroom management strategies, helpful hints, and answers to the questions;
- provides suggestions for leading discussions and synthesizing student understanding;
- gives recommendations for acquiring materials;
- suggests extensions, when appropriate.

Assessment

This module provides teachers several options for assessing students:

- Students record their work and conclusions in their journals. Teachers can assess the level of a student's day-to-day engagement by reviewing his or her daily entries.
- Each activity has a question set that can be the basis of an assessment on that topic.
- The Teacher Pointers suggest alternate ways of exhibiting student understanding such as poster reports, debates, and multimedia presentations.
- Each misconception listed in the "At a Glance" sections has an accompanying question that can be used either to begin a discussion or as a preassessment question to help students focus on the misconception. Student understanding can be assessed at multiple points by obtaining written responses to single preassessment questions that probe for misunderstandings.
- Since one of the best techniques for assessing inquiry learning in science involves having students actually perform tasks that demonstrate their mastery, the case study at the end of the module is the intended assessment of student understanding. By having students discuss the *Pathfinder* landing site in the context of four billion years of Martian history, the case study asks students to develop hypotheses, use evidence to support their hypotheses, and present their ideas in an organized way. As stated in the National Science Education Standards, "A well-crafted justification demonstrates reasoning characterized by a succession of statements that follow one another logically without gaps from statement to statement." Whether the story is a report, presentation, series of experiments, poster or multimedia presentation, the case study is a powerful way to gauge the level of student understanding.

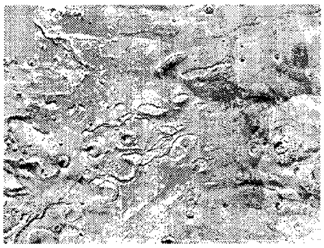


Classroom Management Strategies

Specific classroom managment stratagies relating to each activity are described in the activity notes. For some activities, it may be possible to break the class into several groups which conduct the activity in parallel. Teachers using this approach should ask groups to compare results and to try to explain any major differences observed. It is very useful for students to understand that duplicate experiments often do not produce identical results.

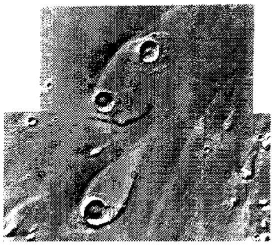
MODULE ACTIVITIES AND THE SCIENCE THEMES

Like Earth, Mars has valleys that seem to be caused by a flowing fluid, presumably water. One can see dendritic drainage patterns as well as flood channels on the Martian surface. This module focuses on whether the channels observed on Mars are evidence of great floods and, if so, on how *Pathfinder* intends to use the debris from such floods to obtain information about four billion years of Martian geologic history.



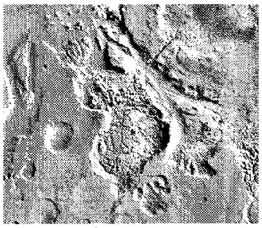
Activity 1 : What Shapes Does Water Flowing Over a Surface Produce?

Using a stream table and setting it at various inclinations, students develop an eye for features associated with flowing water. To consider the idea of whether water once flowed on the surface of Mars, students choose three landforms that seem to have been shaped or created by flowing surface water and discuss how they may have formed both with and without flowing water. Also, by examining how flowing water sorts particles according to size, students see what sediment can reveal about the speed of the water that deposited it. Finally, students examine images of Mars to see if there are any features suggesting the presence of flowing water at one time or another.



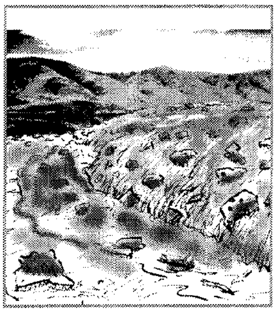
Activity 2 : Can You Make Teardrop Shapes Similar to Those on Mars?

Students study images of the teardrop-shaped landforms and list what they think are the most important reasons for why these landforms took on their particular shapes. They identify the variables and attempt to recreate the teardrop shapes in the stream table. By attempting to create a specific shape in their stream table, students gain experience in experimental design and in how altering variables leads to different results.



Activity 3 : What Is Chaotic Terrain?

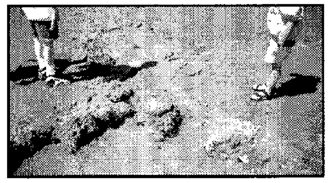
By having ice melt from under a layer of sand and causing the surface to deform, students create a simplified model the formation of chaotic terrain. Then, students compare their models to images showing chaotic terrain on Mars. They learn several identifying features and try to identify additional examples of chaotic terrain seen in the image set. Finally, they consider ways to improve their models to resemble the Martian chaotic terrain more closely.



Activity 4: The Scabland Mystery Story

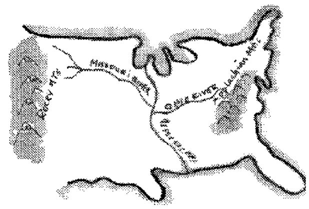
Students read about geologist J. Harlen Bretz's efforts to provide a coherent explanation for the creation of the Channeled Scablands of eastern Washington State and about some of the evidence he used to support his idea of a cataclysmic flood being responsible for its creation. By examining some of this evidence, students hypothesize about processes that might account for these apparently unrelated features, ultimately creating a hypothesis the entire class can support. Next, students look at images of flood channels on Mars and see if their Scabland hypothesis explains anything about the Martian channels. To draw a sharper comparison, students complete a sheet directly comparing some Scabland and Martian features. Finally, students read an essay describing the outcome of Bretz's work and the gradual acceptance of his ideas.

Activity 5: Creating a Large-Scale Model of Catastrophic Flooding



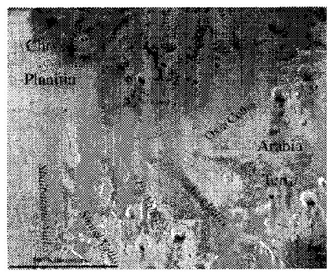
Students model catastrophic flooding. Working at a larger scale than is possible in a stream table -- either at a beach or on a sand-covered driveway — students create a sudden outflow of water and observe the shapes created by the flooding. Students observe separating and rejoining channels, streamlined shapes, ripples and poorly-sorted sediments.

Activity 6: What Can Sand Indicate About How and Where Water Flowed?



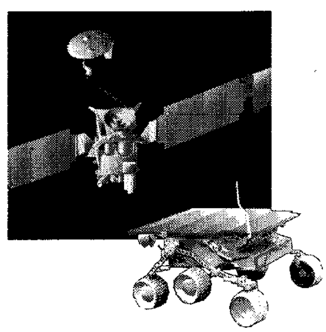
This activity introduces students to one of the main geologic reasons why the mouth of the Ares Vallis is such a desirable landing site for *Mars Pathfinder*. By examining sand samples from different locations, students realize that sediments can provide information about where they originated and how they were deposited. By looking at the abundance of various minerals and the condition of the grains, students formulate a reasonable history for each sand sample. They then locate Ares Vallis on a map and speculate about what *Pathfinder* might find in the sediments there.

The Case Study: Were There Catastrophic Floods on Mars?



Students examine images of the Martian flood channels, focusing especially on Ares Vallis. They analyze the surface features around the landing site and discover that it is located at the mouth of a large channel. Tracing this channel toward its origin, students determine its dimensions and see how the channel emanates from several areas of chaotic terrain. They then use crater densities to determine that Ares Vallis crosses a variety of terrains formed at different times in Martian geologic history. Next, students consider the types of rocks and sediments that *Pathfinder* might find at the mouth of a large flood channel that crosses a landscape with considerable geological diversity. Finally, students write a story explaining how features in Ares Vallis support the idea that there were mammoth floods on Mars and how *Pathfinder* intends to use flood debris to shed light on Martian geologic history.

Preparing for the Missions: What Questions Has This Module Raised?



The final activity invites students to develop an on-going connection with the upcoming Mars missions. By reflecting on their experiences in the module, students articulate questions and pinpoint specific information they would like to obtain. Students create a list of questions that have arisen during their work. They then read about the instruments on the *Pathfinder* and *Mars Global Surveyor* and relate the information these instruments will provide to their questions. Finally, students create a calendar for the missions and consider how they will access the information returned by the probes.

NOTES