MARS EDUCATION PROGRAM

Mars Exploration

The Grand Canyon of Mars and How It Formed

Teacher Handbook

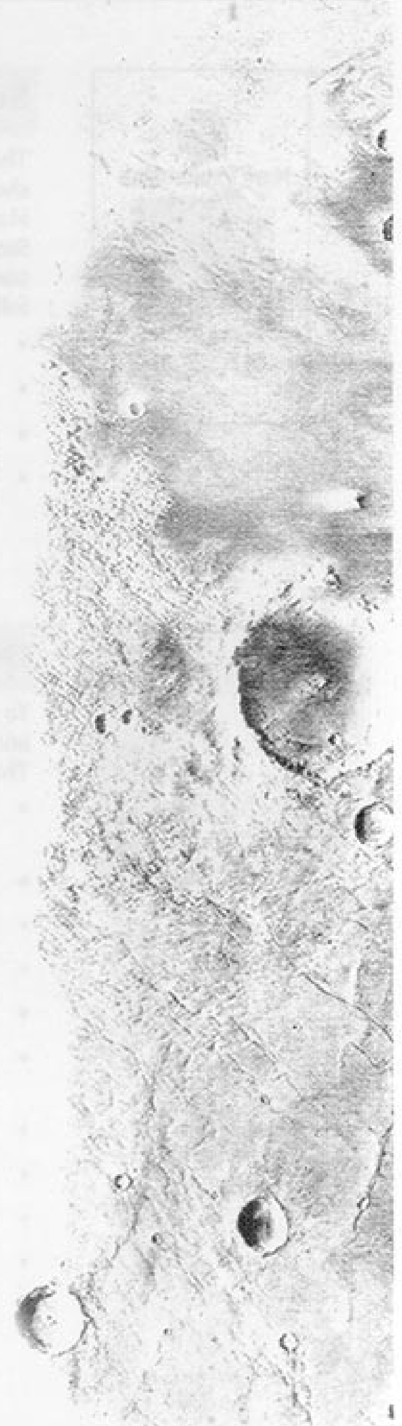
Jet Propulsion Lab

Mars Exploration Education and Public Outreach Program

TABLE OF CONTENTS

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, and 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 Mars 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.



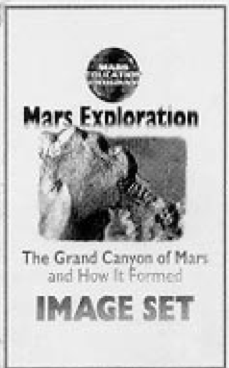
Why Teach This Module?

The activities in the *Grand Canyon of Mars* module investigate some of the processes that created the largest canyon in the solar system. Mars is an excellent place to examine the alteration of a planet's surface because:

- geologic processes have occurred at a mammoth scale, 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.

In addition, because the formation of certain Martian 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 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 not only learn about the formation of the Martian Grand Canyon, but 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:

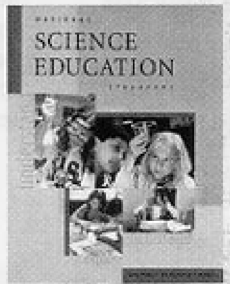
- Activity title and a general description of the activity.
- A simple sketch of the activity setup.
- A table containing any data collected.
- A few conclusions.

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



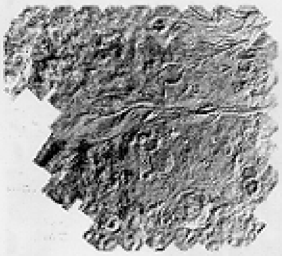
This module provides teachers several options for assessing students:

- 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 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 a 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 weave their understanding of the formation of Valles Marineris into a plausible story, the case study asks students to develop hypotheses, use evidence to support their ideas, 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.

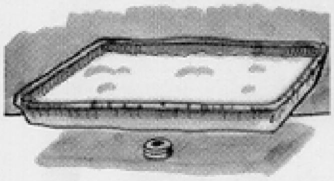
Classroom Management Strategies

Specific classroom management strategies 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

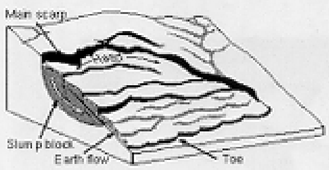


Mars has many canyons and valleys. Some seem to be caused by water while others seem to be caused by the movement of the planet's crust. Like Earth, Mars has dendritic drainage patterns, rifts and flood channels, and this similarity enables students to see how the processes creating these features are alike and different on each planet. This module focuses on the processes that alter a planet's surface in the absence of flowing surface water.



Activity 1 : How Does Uplift Affect A Planet's Surface?

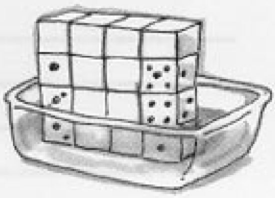
examines uplift, a process that elevated a portion of Mars 11 km (7 mi) above the average surface elevation. The resulting bulge, the Tharsis Rise, is roughly equivalent to the combined size of the United States and Canada. The uplift stressed the surface causing it to rift and form fractures thousands of kilometers long and hundreds of kilometers wide. For reasons that are not fully understood, some of these fractures became enlarged into a 4,000 km (2,500 mi) long system of canyons. This group of canyons is called Valles Marineris, named in honor of the *Mariner* missions that explored Mars from the mid-1960's to the early 1970's. (Note: Valles is the plural form and Vallis is the singular). Students model the effects of uplift by deforming a layer of corn starch on a flexible pan and observing the resulting fracture patterns. On Earth, the Black Hills of South Dakota show a somewhat similar dome effect with radical faults and fractures extending out into the surrounding plains.



Activity 2 : How Does The Flow Of Groundwater Affect A Planet's Surface?

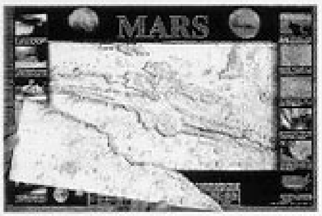
examines sapping and slumping, two processes related to the subsurface flow of water. It is thought that slumping widened some of the canyons of Valles Marineris as much as three times their initial width. Students use a simplified stream table to examine slump formation and to observe sapping. On Earth, slumps commonly erode hillsides such as those in the western United States which have lost their vegetative cover due to fire.

Activity 3 : What Happens When Material Is Removed From Beneath A Surface?



examines subsidence, a process that causes depressions through the lowering of the ground surface. Subsidence may be able to account for the great depth of some of the canyons. To model subsidence, students create a "landscape" of dice and sugar cubes. By dissolve the sugar cubes, they cause the surface of their "landscape" to subside. On Earth, examples of subsidence include sink holes and the lowering of land affected by lowered water tables.

The Case Study : How Did Valles Marineris Form?



is an opportunity to look at Valles Marineris as a whole entity rather than focusing on it piecemeal as in the activities. Making extensive use of the Image Set, students see examples of the processes they modeled earlier in the module and see them in the context of Valles Marineris. They think about how each process (or processes working in conjunction) might have contributed to the formation of Valles Marineris and develop these thoughts into hypotheses. They support their hypotheses with evidence from their modeling, image analysis and experimental experiences and weave the hypotheses and supporting evidence into a story which integrates their understanding and insight.

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

invites students 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* (*MGS*) and relate their questions to the information *MGS's* 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.

NOTES