TEACHER GUIDE

MARS EXPLORATION

Student Data Teams

NASA

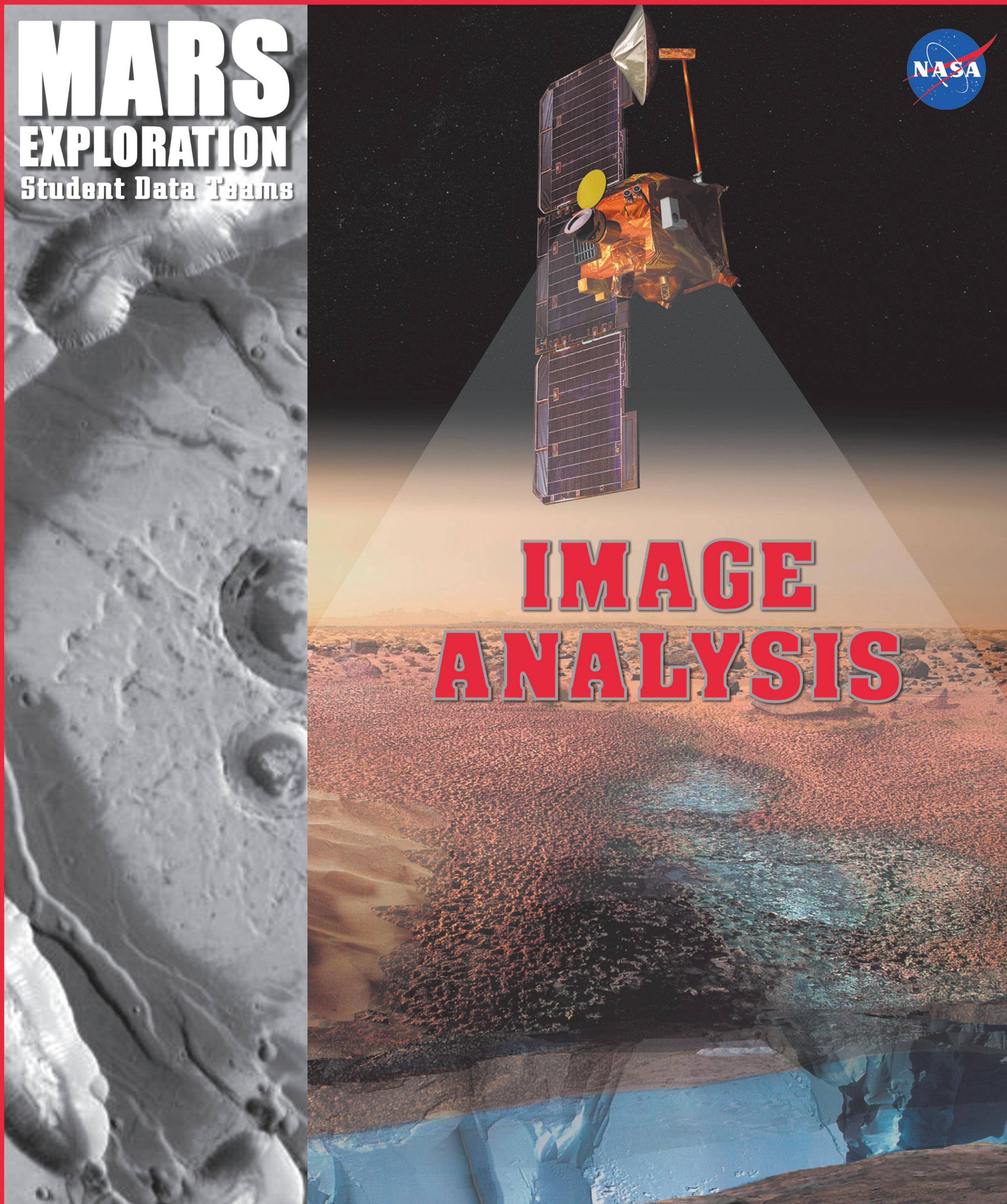

IMAGE ANALYSIS

JPL

ASU Arizona State University

Arizona State University Mars Education Program
http://marsed.asu.edu

JET PROPULSION LABORATORY • ARIZONA STATE UNIVERSITY • MARS EDUCATION PROGRAM

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Teaching Tips

Goals:
Through analysis of Mars images, analyze the distinctive geomorphologic features found on the surface of a planet.

Objective:
Students will:

- Work in cooperative groups to analyze THEMIS visible images of Mars
- Gain an understanding of the scientific inquiry process and the geological history of a terrestrial planet (i.e. Earth and Mars) by analyzing THEMIS visible images of Mars.

Time Frame:
1-2 class periods (~45 minutes each)

National Science Education Standards: *(See end of teaching tips for more detail)*

- Standard A: Science as Inquiry
- Standard D: Earth and Space Science
- Standard G: Nature and History of Science

National Mathematics Standards: *(See end of teaching tips for more detail)*

- Numbers and Operations
- Measurement

Suggested Grade Level: 5th – 12th grade

Materials Needed per Group (4 students per group):

- 1 laminated large THEMIS visible image (11” x 17” or larger)
- 1 context image (8.5” x 11”) of the respective THEMIS visible image showing the surrounding area in which the image was taken. Sample images available at http://msip.asu.edu/sample.html or lendable images can be requested by contacting msip@asu.edu
- Mars Image Analysis Data Log Chart
- Mars Image Analysis Surface Feature ID Charts (4 pages)
- Water-soluble overhead transparency markers
- 2 Rulers
- 2 Calculators
- Globe or map of Mars (For maps of Mars go to the download link at http://msip.asu.edu and access the MOLA map JPG.)

Introduction

How do scientists understand and interpret the surface features of Mars from orbit and determine if a proposed landing site will meet the mission's science goals? The distance to Mars varies between 80 and 240 million kilometers (50 – 150 million miles). The planet is therefore studied using remote sensing techniques. As part of the science studies from the Mars Global Surveyor and Mars Odyssey missions, images from these spacecraft have provided valuable information that has been used to understand the surface of Mars in the context of finding and evaluating possible landing sites. The images from these orbiters have also given scientists a better understanding of the past geologic history and the present conditions on Mars. The geological processes that occur on Mars are similar to those that occur on Earth. Comparative planetology, especially between Earth and Mars is widely used by scientists currently researching Mars. This activity will provide a bridging context in which your students will experience a current and real-world application of how scientists think using authentic data and how the process of science evolves. By taking advantage of the inherent excitement of studying Mars, your students will be more motivated to better understand our own planet.

Planetary missions have to balance two critical areas – engineering and science. To have a successful mission, the engineers have to help to ensure the success of the spacecraft and mission success for landing by spacecraft design and landing site safety considerations. On the other hand, scientists want to argue for the area with the richest science return. These two groups don't always agree, but in real life must come to a compromise for a mission to go forward.

This activity will place students in the role of scientists as they analyze the geological processes that may have taken place using a visible image of the Martian surface taken with the Thermal Emission Imaging System (THEMIS). Your students will be able to make a recommendation as to whether or not they feel an area is scientifically interesting enough to be considered as a potential landing site. Students will also use NASA's four goals for the exploration of Mars to justify their decision. NASA's goals are as follows:

1. **Determine if life ever existed on Mars**
2. **Characterize the climate of Mars**
3. **Characterize the geology of Mars**
4. **Prepare for future human exploration of Mars.**

As was done with the Mars Exploration Rover potential landing sites, those recommended areas would then be evaluated using a whole different set of criteria by the engineers.

As your students analyze their image(s) of Mars, the focus should be on the process being used rather than "correct" answers. Students should be able to justify the process they used to analyze and develop an understanding of their image. By using that process, they will be able to justify their decision as to whether or not they would recommend their area of Mars as a potential landing site, and have achieved the objective of this activity.

Background of Image Materials (to be shared with students by teacher)

Context Image
The context image shows a Mars Orbiter Laser Altimeter (MOLA) shaded relief map showing the area in which the THEMIS visible image was taken. The targeted THEMIS visible image is within the blue box shown in the center of the context image. Each context image provided also includes the THEMIS image identification number and the name of the region of Mars in which the image was taken. Also included is information that will be useful for this activity:

a. **Latitude:** Latitude (and longitude) is provided to identify (on a Mars globe or map) where the image was taken. Latitude is always provided here as north latitude. Students need to understand that 37.4 is 37.4 degrees North but –37.4 would indicate 37.4 degrees South.

b. **Longitude:** Longitude will always be provided as east longitude.

c. **Sun Angle:** This information provides the angle of the sun when the image was taken. This would be used if the students wanted to measure depth or heights of features using the sun angle.

(Note: For all images in this activity, the sun is illuminating from the left.)

As most scientists record as much information about their acquired image as possible, the following data is provided. This information is not required for this activity:

d. **Orbit:** The number of the orbit in which the image was acquired.

e. **VIS Start ET:** The number of seconds (in ephemeris time or ET) when the VIS (visible) image was taken. Ephemeris time is the number of seconds since this astronomical epoch began (12:00am on January 1, 2000, GMT).

f. **VIS Image ID:** Each THEMIS image has an identification number according to what number image it was in relation to all the other images taken during this orbit. (For example, VIS Image ID 005 means that this particular VIS image was the 5th image taken during its respective orbit.)

g. **Mars Local Time:** The time (on Mars) when the image was taken. The time is based on a 24-hour clock and uses percentages of hours rather than minutes. For example, if an image was taken at 15.75, it would be 3pm and 75% of an hour, or 3:45pm. If an image was taken at 16.2, the time would be 4pm and 20% of an hour or 4:12pm.

(Note: In each context image the northernmost part of the image is at the top.)

THEMIS Visible Image
The THEMIS visible image includes the name of the region in which the image was taken and also includes the image identification number in the lower right hand corner. This image identification number should match the image identification number on the context image. THEMIS visible images have a resolution of about 18 meters per pixel. The top portion of the image is the northernmost part of the image. Each complete THEMIS visible image consists

of 19 framelets (almost seen as individual rectangles joined together). THEMIS visible images are approximately 18 km (~11 miles) across and 57 km (~35 miles) in length.

Other Handouts Provided
Included in this lesson is a Data Log Chart that will allow students to fill in the information they will obtain as they look at the THEMIS visible image. Also included are Surface Feature ID Charts. These four charts provide an example of what a particular surface feature may look like on Mars and have some written details about the feature in general and how it may form. The MOLA map will give your students an additional resource to examine the larger context in which their image was taken.

Procedure:

1. Students should be given an overview of the context image, the THEMIS visible image and the other materials they will be using for this activity (see above explanations).

2. Using the context image and/or a map or globe of Mars, students should answer the questions on the Student Worksheet Part I.

3. Using the Surface Feature ID Chart, students should identify the different features in their THEMIS visible image. Students can identify their features on the image itself as well as on the Data Log Chart provided. This part of the activity (Part II) also asks students to hypothesize as to how they think these features formed by using the written information provided in the Surface Feature ID Chart.

4. Using the information provided in Student Worksheet Part III, students should rank their labeled features according to age with one (1) being the oldest feature and subsequent numbers being younger features. Students should fill out this information on the Data Log Chart.

5. Using the information provided in Student Worksheet Part IV, students should measure the different features in their image and includes the information in the Data Log Chart.

6. Using the information provided in Student Worksheet Part V, students should determine whether or not this area of Mars is scientifically interesting enough to be considered as a potential landing site.

Assessment:
Students will be assessed based on their written explanation of how they arrived at their decision to recommendation (or not recommend) the area of Mars they analyzed as a potential landing site. Their explanations should show evidence of an understanding of the analysis process they completed throughout the activity.

Extensions:

- You may consider having your students do the Marsbound! activity to actually design a future lander mission to Mars. Students can use the blank Marsbound! cards to help create their future lander that may include technology that is not included in the given Marsbound! card set.

- Students can calculate depths and heights of features by dividing the length of a shadow by the tangent of the sun angle (sun angle information is provided on the context image). To do this, students would use the following steps:

    - Measure the width of the shadow in centimeters.

    - Using the calculated scale factor (Part IV of the Mars Image Analysis activity), convert the shadow measurement to kilometers.

    - Divide that calculated measurement by the tangent of the sun angle (provided on context image) to compute the depth of the feature being observed.

- Students can analyze and label images using computer applications such as Adobe Photoshop.

Note: Consider having your students complete the Mapping the Surface of a Planet activity prior to the Mars Image Analysis activity. This activity provides great information allowing students to understand features found on Earth that we can compare to features found on Mars. It will also allow students to understand how you can determine the surface history of a planet or area of Mars (or Earth!). The Mapping the Surface of a Planet activity can be downloaded at http://marsed.asu.edu.

This activity can be used as a part of the Mars Student Imaging Project (MSIP). It can be used to help students analyze images of Mars that may related to their project/research or can be used as the archived format of the program. For more information on the Mars Student Imaging Project, go to http://msip.asu.edu.

Students can analyze other THEMIS visible images available on the http://themis.asu.edu website.