Mars Image Analysis Activity

Introduction:
How do scientists determine if a proposed landing site on Mars will meet the mission's science goals? Mars varies from being 50 – 150 million miles away from Earth and must be studied using remote sensing techniques. Images from the *Mars Global Surveyor* and *Mars Odyssey* spacecraft have provided valuable information that can be used to find and evaluate possible landing sites. These orbiters have also given scientists a better understanding of the past geologic history and the present conditions that exist on Mars. The geological processes that occur on Mars are similar to those that occur on Earth. By taking advantage of the inherent excitement of studying Mars your students will be more motivated to better understand our own planet.

This activity will place students in the role of scientists in analyzing the geological processes that may have taken place in an actual image of the martian surface. This will allow students to determine if an image contains geological features that are scientifically interesting and where a lander might be sent to investigate a particular portion of the image.

Objective:
Students will 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.

Suggested Grade Level: 5^{th} – 12^{th} grade

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

Materials Needed per Group (4 students per group):
- -1 laminated large THEMIS visible image
- -1 context image of the respective THEMIS visible image showing the surrounding area in which the image was taken
  (Images available at http://msip.asu.edu or lendable images can be requested by contacting msip@asu.edu)
- -Water-soluable overhead transparency markers
- -2 Rulers
- -2 Calculators
- -Globe or map of Mars (For a map of Mars go to http://themis.asu.edu and access the data release link.)

National Science Education 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.
2. Conduct a scientific investigation.
3. Use appropriate tools to analyze and interpret data.
4. Develop descriptions and explanations using evidence.

5. Think critically and logically to make relationships between evidence and explanations.
6. Communicate scientific procedures and explanations.

Content Standard D: As a result of their activities, all students should develop an understanding of:

1. Structure of the Earth system
2. Earth's history

Content Standard G: As a result of their activities, all students should develop an understanding of:

1. The nature of science

Background:

This activity uses Thermal Emission Imaging System (THEMIS) visible images of Mars that cover an area of approximately 18 km (~11 miles) across by 57 km (~35 miles) in length. The context image shows the actual target of the image that was acquired with the THEMIS visible camera on board the *Mars Odyssey* spacecraft (context image and THEMIS image details provided below). In this activity, your students will have the opportunity to examine a THEMIS visible image of Mars and analyze it for a number of purposes. You may decide which objectives you would like your students to work on based on the grade level of your students and how much time they will be given to work on the activity.

Background of Image Materials

The **context image** shows the orbital track of the spacecraft (within the red and green parallel lines) draped over a Mars Orbiter Laser Altimeter (MOLA) relief map indicating landforms. The targeted THEMIS visible image is the small grey box shown within the larger red box targeted in the center of the context image. Each **context image** is imprinted in the upper right hand corner with the THEMIS image identification number and the name of the region of Mars in which the image was taken. Below the context image, in the grey chart, the following information 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 identified here as a 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 longitudes.
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.

The following additional data is provided for informational purposes only and 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 when the VIS (visible) image was taken.

f. **VIS Image ID:** Each THEMIS image has an identification number according to what number visible image it was during this orbit. (For example, VIS Image ID 005 means that this particular VIS image was the 5th visible 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 North is to the left.

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 18 meters per pixel. The top portion of the image is the northern most 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 across and 57 km in length (the length may vary).

If you want your students to use a ruler to calculate widths of craters or lengths of features, you could have them figure out the scale of the image. If students know that the width of the THEMIS visible image is 18 km on Mars they can use a simple ruler to figure out the scale of the image. To do this, they would measure the width of the THEMIS visible image in centimeters and divide that number into the 18 km. The calculated answer will represent what 1 image centimeter is equivalent to in terms of kilometers on Mars. For example, if they were to measure the width of the image and got 35.3 cm, they would calculate 18 divided by 35.3 cm and get 0.51 (rounding to the nearest hundredth). Therefore, one image centimeter would be equivalent to 0.51 km on Mars in this example. If students were to measure a feature that was 11 image centimeters in length they would multiply 0.51 times that measurement (11) and find that feature to be 5.5 km on Mars.

Sample objectives that can be met with this activity are as follows:

1. Identify geographically where on Mars an image is located.
2. Identify the region of Mars in which the image is located.
3. Describe the type of region in which this image is located on Mars.
4. Identify what types of features (landforms or geologic features) are found in this area of Mars.
5. List what types of scientific topics could be addressed in this area of Mars based on the identified landforms (*i.e* craters, volcanoes, canyons).
6. Create a specific scientific question that this area of Mars could answer.
7. Based on the scientific question(s) the students have created, make observations to evaluate if this area is scientifically suitable to answer that question(s) and if the area would be a safe landing site for a lander capable of making a pinpoint landing on Mars.
8. Measure features found in the THEMIS visible image to obtain a better understanding of the morphology (shape of the landforms) of the area.

9. Create the possible "story" of the image; what is the geological history and the present conditions that exist on Mars to have made this area appear the way it does today.

Procedure:

1. Identify the objectives you have chosen for your students to complete
2. Students should be given an overview of the context image and THEMIS visible image they will be using for this activity (see above explanations).
3. Using the context image and/or a map or globe of Mars, students should answer the questions on the Student Worksheet (Part I). This student worksheet addresses the first seven objectives listed above.
4. Student Worksheet Part II asks the students to calculate measurements of the features found in their image.

Extentions:

- Students can create a plan for a future lander. Keeping in mind that the region shown in the THEMIS visible image is quite small (~18 km X ~57 km), students would need to assume that a lander could land at any specified location on the image. Students would base their scientific instruments and plan on what scientific question(s) they want to answer.

- You may consider having your students do the *Marsbound!* activity to actually design a mission to Mars (lander, orbiter or fly-by mission). Students could 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 could calculate depth and heights of features by dividing the length of a shadow (in kilometers) by the tangent of the sun angle (sun angle information is provide on the context image).

- Students could put together a PowerPoint presentation of Part II or the above-mentioned "lander" extension (or both) to present to the class.

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://msip.asu.edu.

Name_____

Student Worksheet – Mars Image Analysis Activity
Part I

How do scientists determine if a proposed landing site on Mars will meet the mission's science goals? Mars varies from being 50 – 150 million miles away from Earth and must be studied using remote sensing techniques. Images from the *Mars Global Surveyor* and *Mars Odyssey* spacecraft have provided valuable information that can be used to find and evaluate possible landing sites. These orbiters have also given scientists a better understanding of the past geologic history and the present conditions that exist on Mars.

In this activity, you will look at a Thermal Emission Imaging System (THEMIS) visible image of Mars to determine the landforms (the morphology) of the area. You will also determine if it would be a scientifically interesting area and one in which a question about Mars could be answered. You will also evaluate whether this area would be a suitable landing site for a future lander mission.

Using the context image and/or a globe or map of Mars, please answer the following questions:

1. What is the latitude and longitude on your THEMIS visible image of Mars?

2. In what area/region was your THEMIS visible image of Mars taken?

3. Using the context image, describe the type of area the THEMIS visible image was taken in (*i.e.* Is it a heavily cratered area? Is it near a possible outflow channel or ancient volcano, etc.)

4. Using the THEMIS image, what types of landforms can you identify?

5. What questions about Mars could be answered using this THEMIS image?

6. Based on the type science question(s) you created in the above question, would you recommend this area of Mars as a suitable and safe landing site for your scientific purposes? Why or why not?

Name_____

Student Worksheet – Mars Image Analysis Activity
Part II

Suppose you want to have more information to decide if this is a suitable and safe landing site for your future lander. By carefully making observations and measurements of your THEMIS visible image, you will gain a better understanding of the past geologic history and the present conditions that exist in this area of Mars.

1. Using a non-permanent marker, label the features you see in your THEMIS visible image of Mars.
2. Using a ruler and a calculator, calculate the lengths and widths of these features.
3. Create an organized list of your measurements below.

This analysis of your image will help you understand this area of Mars better and will allow you to understand the "story" of what happened in the area shown in the image.

Scale:
THEMIS visible images have a resolution of 18m per pixel. In order to correctly measure the features in your image, you need to know the scale of the image you are working with. To get that scale you would measure the width of the image in centimeters and divide that into 18. (Why divide into 18? The actual width of a THEMIS visible image is 18 km on Mars.) Once you calculate that answer that will tell you what 1 image centimeter is equivalent to in terms of kilometers on Mars. For example, if you measure the width of your image and get 35.3 cm, you would compute 18 km divided by 35.3 cm and get 0.51 (rounded to the nearest hundredth). That would mean that 1 image centimeter would be equal to 0.51 kilometers on Mars. If you measure a feature that is 11 centimeters, you would multiply those 11 cm times 0.51 to find out how large that feature is in kilometers on Mars. Try it but make sure you find the scale of the image you are working with!

Once you have finished labeling and measuring your features, write the "story" (the geologic history and the present conditions that exist) of this area of Mars.