Arizona State University

National Aeronautics and Space Administration

Mars Uncovered

Revealing the Geologic History Through Mapping

An inquiry-based, critical thinking lesson about interpreting the geologic history of regions on Mars

STUDENT GUIDE

STUDENT WORKSHEET 1

Initial Observations and Strategies

Name(s) ___________________________________

Date _____________________________________

Look at the Thermal Emission Imaging System (THEMIS) Daytime Infrared (IR) image mosaic your teacher has given you. You will be investigating this image throughout this activity looking for clues about the geologic history of this region. Areas where no THEMIS data has been acquired yet are seen as vertical black lines on the image.

1. What is the name of your region on Mars: ____

2. What are the two main geologic features seen in your image? Explain the process of how these features form.

   A. Geologic Feature: ________________________________

      Formation:

   B. Geologic Feature: ________________________________

      Formation:

3. List two pairs of geologic features (two craters, or a crater and a channel) for which you can tell the relative ages (older/younger). Briefly describe where those features are on the image mosaic (NW part of image, center of image, etc.):

   A. Two Features:_____________________________ Location:_____________________

      Younger Feature:______________________________________

      Older Feature:____

   B. Two Features:_____________________________ Location:_____________________

      Younger Feature:______________________________________

      Older Feature:____

4. Describe two methods (strategies) you used to determine which features are younger/older.

   A.

   B.

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Revealing the Geologic History Through Mapping

OBJECTIVE:
Make a simple geologic map of a region on the surface of Mars and interpret the region's geologic history using relative age dating.

BACKGROUND INFORMATION:
Planetary scientists make geologic maps of Mars to understand the history of particular regions. The maps show present-day features along with evidence of past events that modified or changed the region. Scientists study these maps, looking for clues to determine what geologic events have occurred. An important technique is called **relative age dating**.

Relative age dating uses inference (which is often just common sense) to reveal the sequence of events that shaped a planetary surface. While exact dates in years can not be determined, noting which event occurred before or after a different event lets you reconstruct a relative-age geologic history. On Earth, geologic maps are made by scientists on foot in the field, plus photographs taken from airplanes or Earth-orbiting satellites. On Mars, maps are made using photographs (images) taken by orbiting spacecraft. (In very local areas, rovers have begun to act like scientists on foot.)

Over the past 30 years, cameras on spacecraft have taken lots of images from above the martian surface. Like puzzle pieces, individual images of specific areas can be put together to create what scientists call a mosaic. Image mosaics let you look at a large region, analyze it, and interpret its geologic history.

This activity will put you in the role of a scientist. You will use image mosaics taken with the Thermal Emission Imaging System (THEMIS). This camera system is onboard NASA's Mars Odyssey orbiter. THEMIS has taken hundreds of thousands of images of Mars that are available on the Internet at http://themis.asu.edu.

THEMIS (pictured on the left) is a two-in-one camera system:

- Visible Imaging System:
  - Shows the morphology or shape of the surface
- Infrared Imaging System:
  - Can tell us the temperature of the surface (daytime and nighttime)
  - Provides information about what materials on the surface are made of
  - Daytime infrared images can also show the morphology or shape of the surface in much the same way visible images do

This activity will use mosaics of daytime infrared THEMIS images. Although infrared mosaics provide information on both the morphology (the shape of the surface) as well as the temperature of the surface, for this activity, you will focus only on the morphology, identifying features such as craters and channels. As you map a region, it is important for you to be able to:

- Distinguish between preserved, modified, and destroyed craters
- Understand different relative age dating principles

These are both relative age dating techniques. They will help you better interpret the sequence of events that made a surface look the way it does today.

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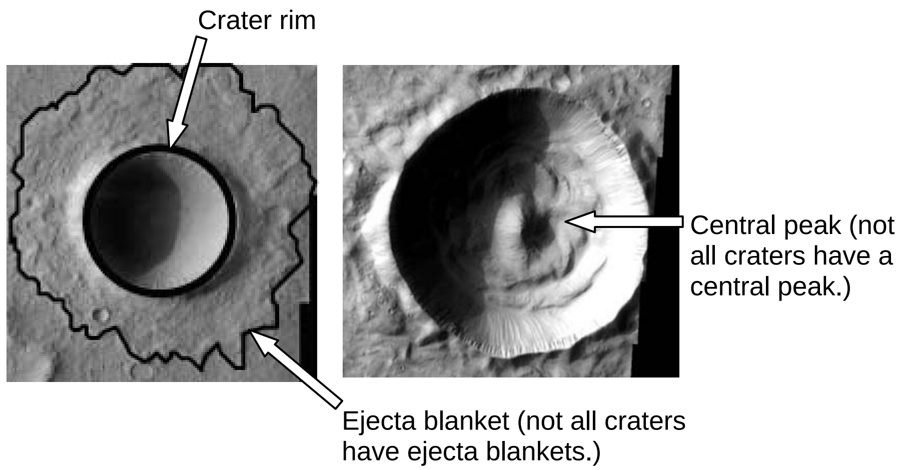
Crater Classifications

We can classify impact craters into three general categories or classifications based on their appearance. These three categories give clues about the history (or relative age) of the crater. We cannot identify the exact age of a crater on Mars, but relative ages for different craters can help us develop a sequential history.

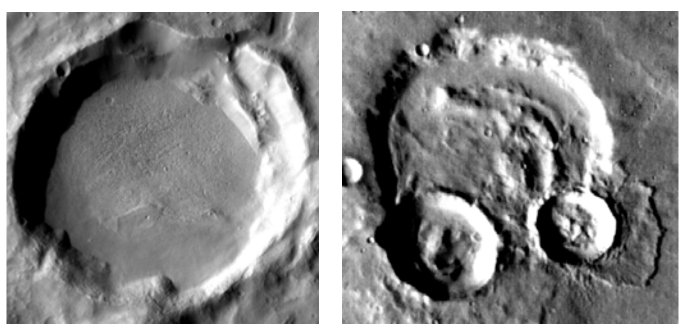
I. Preserved Craters:

- Near perfect craters
- Raised rims
- Look new
- Can sometimes see ejecta blanket or central peak
- Young crater



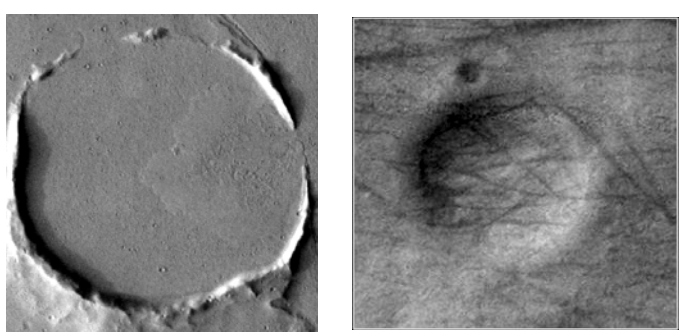
II. Modified Craters:

- Craters that have been changed or modified by:
  - Erosion (wind, water or lava)
  - Other impacts
- Sometimes crater ejecta is visible but looks eroded
- Crater may have smooth floor (partially filled in with material or sediment)
- Middle-aged craters



III. Destroyed Craters:

- Look very worn away
- Rims are broken
- Have been severely changed or modified
- Crater has been filled in almost completely by sediment
- Very old craters



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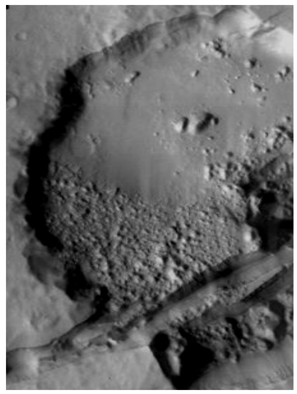
Relative Age Dating Principles

Scientists use two basic rules or principles to help determine the relative age of craters or other features on a surface. They are as follows:

I. Cross-Cutting Relationships:

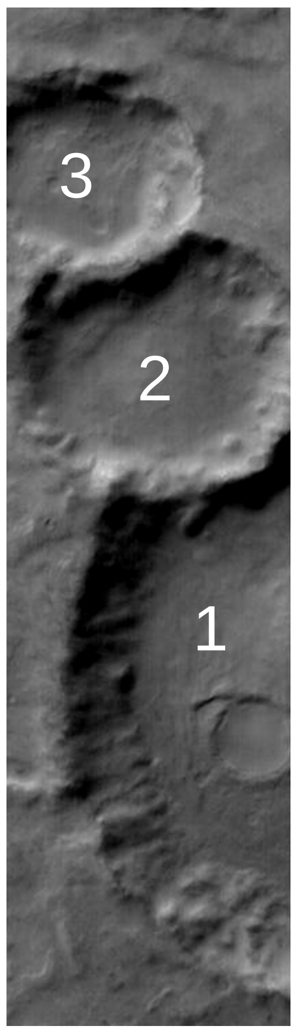
- A crater (or any other feature) can be cut by another feature.
- The feature cut is older than the feature that cut it.



Crater shown here is older than the fracture (crack) that cut through it.

II. Principle of Superposition

- When one feature is on top of another feature, the feature on top is younger.
- The feature on the bottom is the older feature.



Crater #1 is partly covered by crater #2, so crater #1 is older.

Crater #2 is partly covered by crater #3, which makes crater #2 older than #3.

By inference then, crater #1 is the oldest and crater #3 is the youngest.

Student Worksheet 2

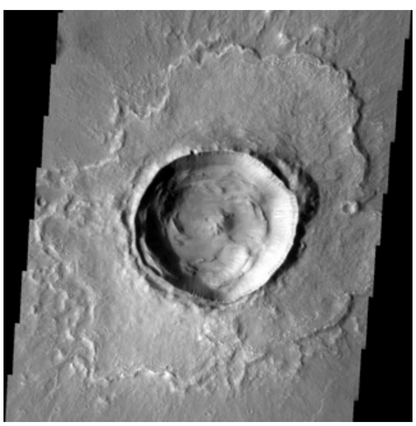
Classifying Craters

Name(s) ___________________________________

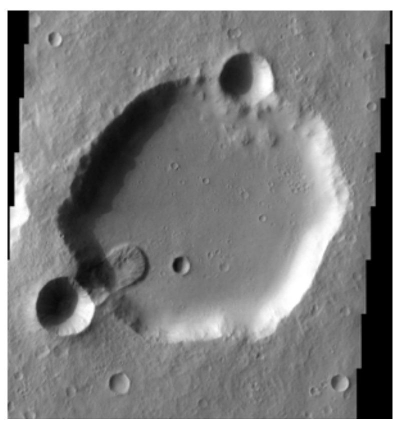
Date ______________________________________

Based on the *Crater Classification* information sheet, classify the craters at the bottom of the page. Be sure to explain your reasoning for each classification.

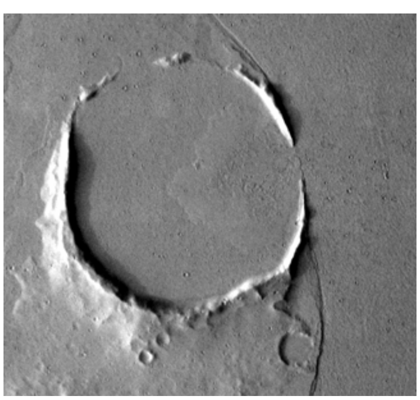
CRATER IMAGE	CRATER CLASSIFICATION (Preserved, Modified or Destroyed)	REASONS
Crater A		
Crater B		
Crater C		
Crater D		



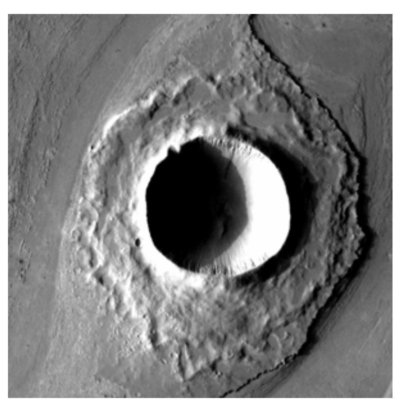
Crater A



Crater B



Crater C



Crater D

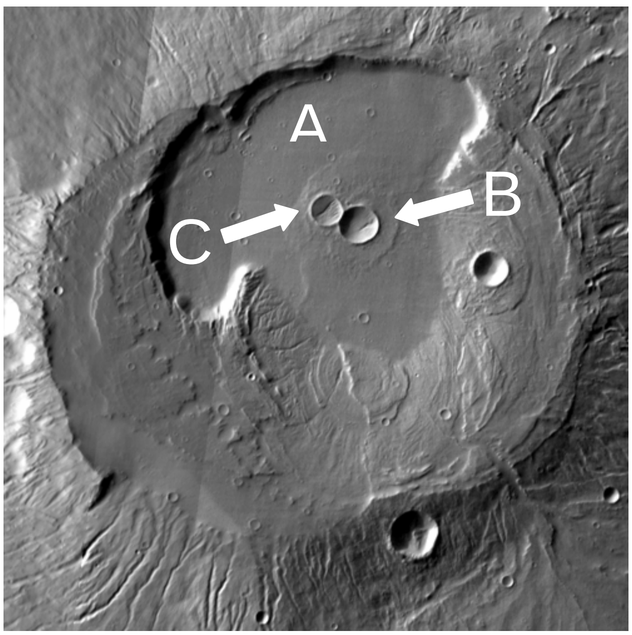
Student Worksheet 3

Relative Age Dating Principles

Name(s) ________________________________

Date __________________________________

Based on the two relative age dating principles (cross-cutting relationships and superposition), write your interpretation of the relative ages of the features in the following images:



Oldest Feature: ________

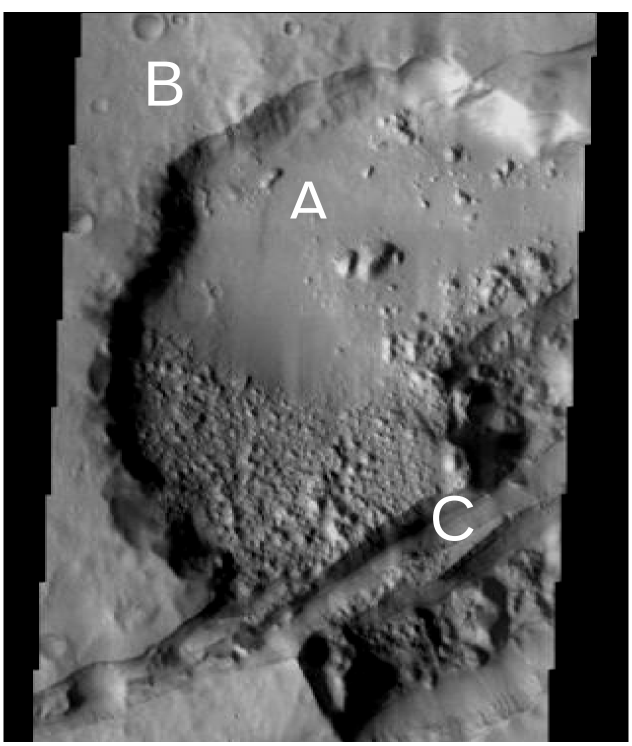
Younger Feature: ________

Youngest Feature: ________

Please explain your answers:

Which principle(s) did you use to choose your answer?

____



Oldest Feature: ________

Younger Feature: ________

Youngest Feature: ________

Please explain your answers:

Which principle(s) did you use to choose your answer?

____

Student Worksheet 4

Creating a Surface Feature Map

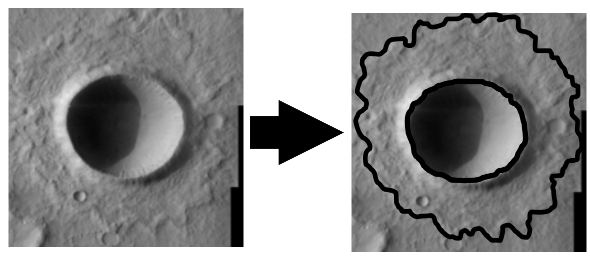
Now you know how to classify craters and are familiar with relative age dating principles. You can now create a feature map of your region of Mars that will help you interpret the geologic history.

In order to create your feature map, you will need to put a piece of transparency paper over your THEMIS mosaic image. Using paper clips, secure the THEMIS image and your paper together.

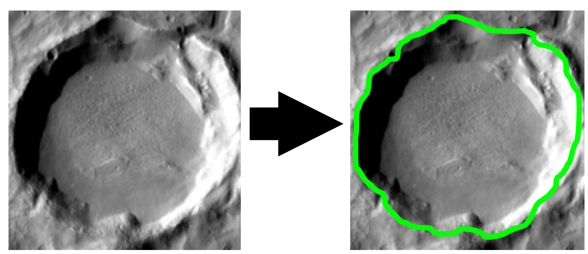
Using your observations and erasable markers, identify the features listed below to create your map. Keep in mind that some features may be too small to map. Use your best judgment to decide what may be too small to map and in determining how to the outline or color features. Outline or color the features as indicated below.

Feature **Colored Feature**

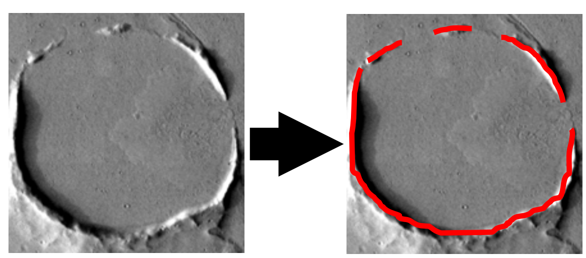
1. **Preserved Craters**: Carefully outline the rims and ejecta (if visible) of all preserved craters in **BLACK.**



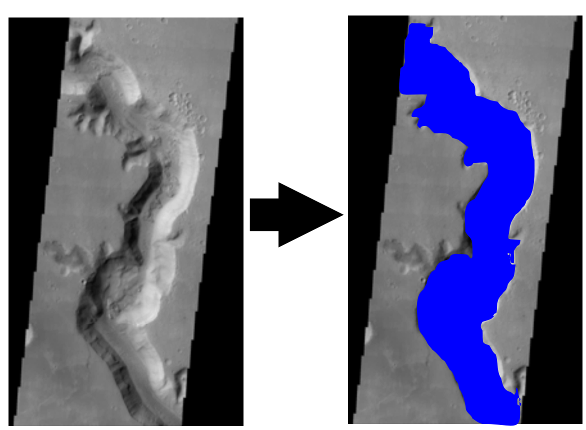
2. **Modified Craters**: Carefully outline the uneven, or eroded rims and ejecta (if visible) of the modified craters in **GREEN.**



3. **Destroyed Craters**: Carefully outline the very eroded crater rims in **RED.**



4. **Channels:** Color (not outline) all channels in **BLUE.**



STUDENT WORKSHEET 5

Interpreting the Geologic History

Name(s) ________________________________

Date ___________________________________

Once you have made your feature map, you are now able to answer some questions and interpret the geologic history of your region. Be sure to name the age dating technique you used for each answer.

REGION NAME: ______________________________________

1. Which is older – the channel(s) (blue) or the destroyed (red) craters? How do you know?

2. Which is older – the channel(s) (blue) or the modified (green) craters? How do you know?

3. Which is older – the channel(s) (blue) or preserved (black) craters? How do you know?

4. Which are older – most large craters or smaller craters? How do you know? Why do you think this is?

5. Which features are oldest, youngest, and of medium age?

Student Worksheet 5
Interpreting the Geologic History
(cont'd)

6. Scientists don't always agree, but they try to convince each other with logical reasons for their interpretations. Discuss and defend your answers to questions #1 through #5 with another group that is studying the **same region**. Change any of your answers to questions #1 through #5 if you feel it is necessary. Fill out the table below after your discussion.

Question #	**Did you agree or disagree with the other groups answer**	**Did you change your answer (yes or no AND why) (Be specific and use 'geologic reasons')**
1		
2		
3		
4		
5		

7. Write your interpretation of the geologic history (the sequence of events that made this area look the way it does today) of this region of Mars. You can use this sample starting sentence or create your own. Use additional paper as necessary.

In the __________________________ region of Mars, there was a lot of geologic activity that modified the surface. First, what happened was…..

STUDENT WORKSHEET 6

Initial Strategies and Future Investigations

Name(s) ___________________________________

Date ______________________________________

1. Look back at question #4 from *Student Worksheet 1*. List each of your initial strategies in the first column provided below. In column two, indicate if you feel it was a valid scientific strategy (method) to use. Use the knowledge you acquired after completing the lesson to make this decision. In the third column, state the common scientific name (if one exists) for the strategy you listed (crater classification or one of the relative age dating principles). If you feel your strategy is valid but there is no name for that strategy, create a name for that strategy that you feel is appropriate. If you feel the scientific strategy is not valid, leave the last column blank.

Initial Strategy Used	**Valid Scientific Strategy (Yes or No)**	**Common Scientific Name (if applicable)**

2. After creating, observing and interpreting your feature map, list at least two questions you have about channels or craters on Mars and how would you go about investigating each question?

Question about craters or channels on Mars	**How would go about investigating your question?**
1.	
2.	

NOTES

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http://marsed.asu.edu

http://msip.asu.edu