



Mars Image Analysis

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Mars Image Analysis

Objectives of the Activity:

Students will:

- Engage in a hands-on, critical thinking and collaborative approach to studying images of Mars.
- Use observations, inferences, and measurement to make interpretations of geologic processes that may have occurred.
- Interpret those processes into a geologic history of the Imaged region.



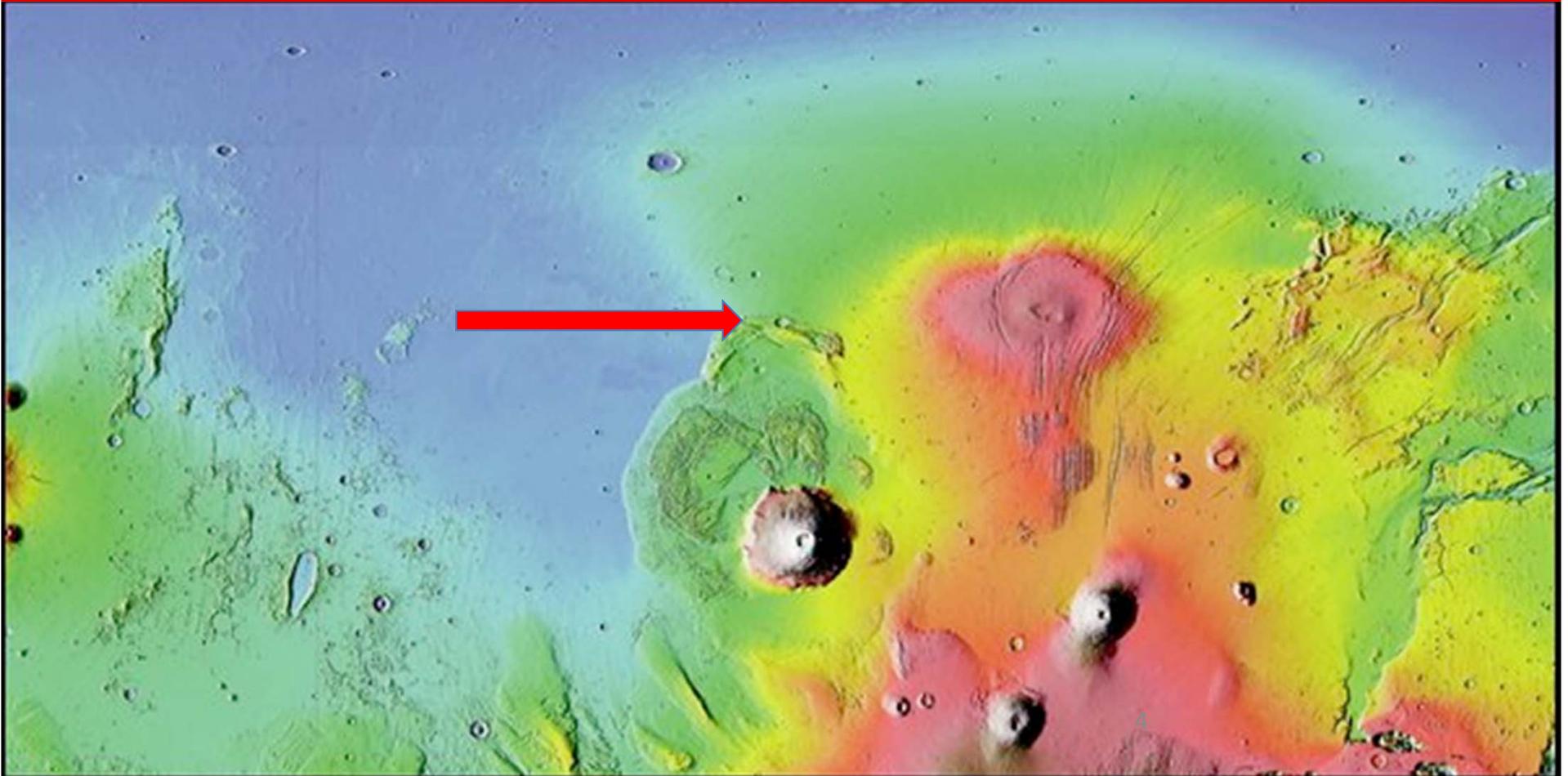
5 E Learning Cycle

Engage



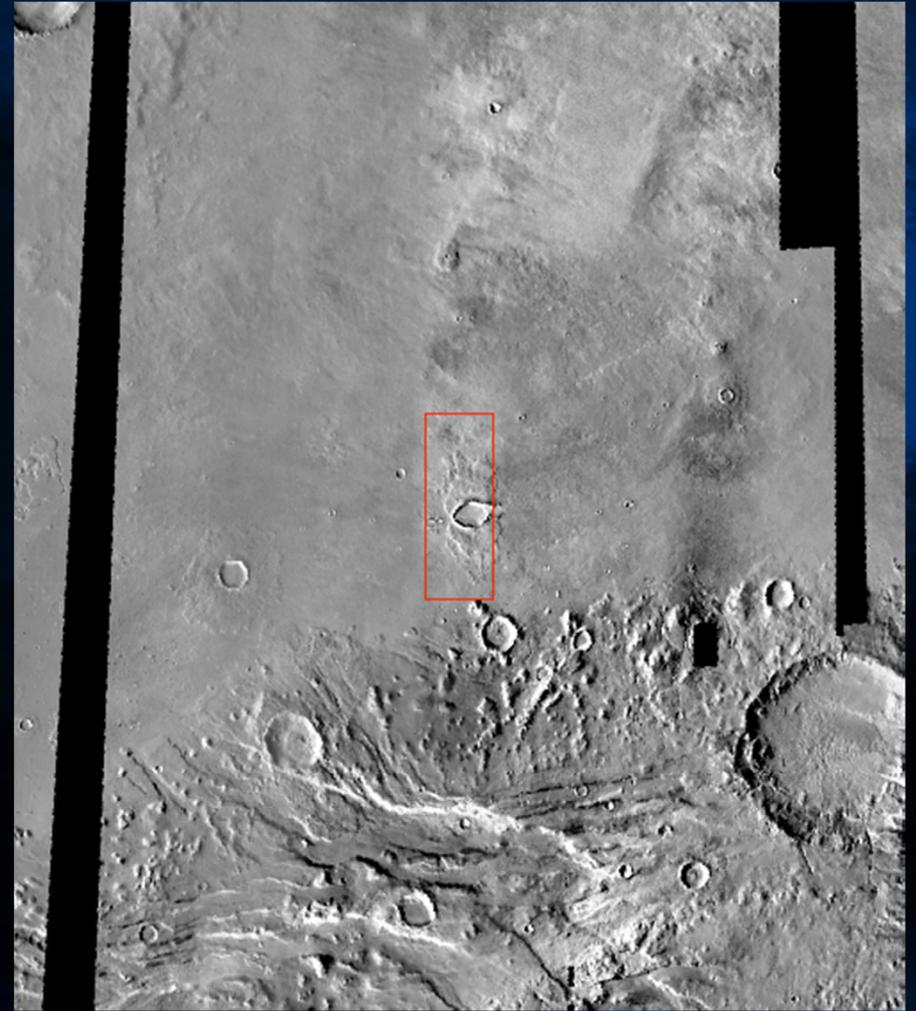
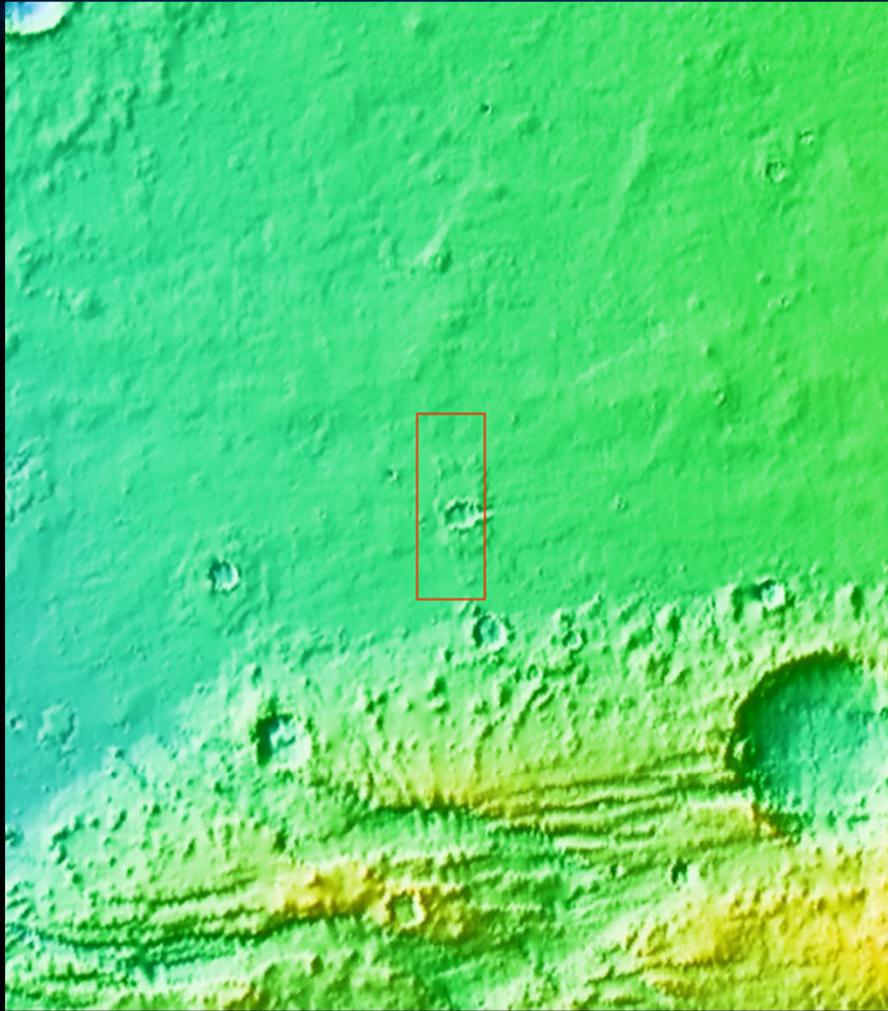
Mars Image Analysis

What can you tell from a picture?





Mars Image Analysis





Mars Image Analysis

- New Conclusions?
- What information could you use from all of the images to gather a better understanding of the geologic history of the area?





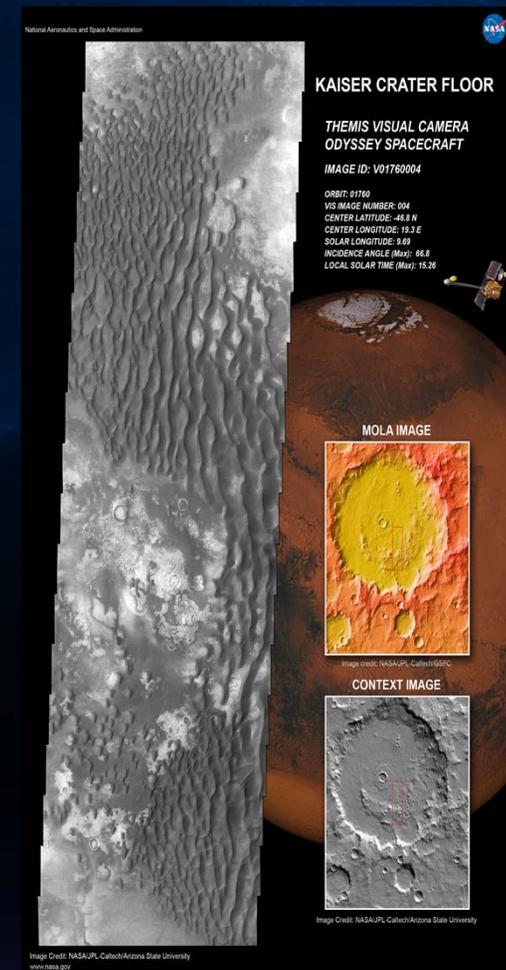
Mars Image Analysis

Activity uses images taken by the Thermal Emission Imaging System (THEMIS) Visible Camera onboard NASA's Mars Odyssey spacecraft.

MARS ODYSSEY

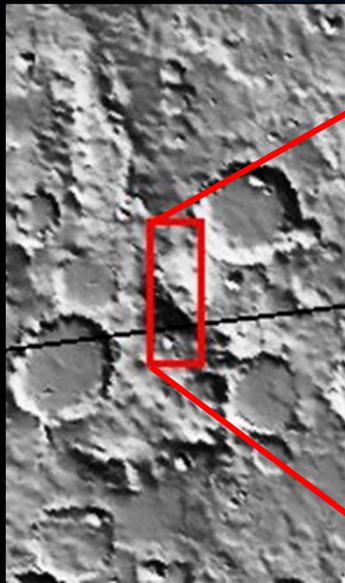


THEMIS visible images show the morphology or shape of the surface (geologic features).





Getting Familiar with Images of Mars



Context Image

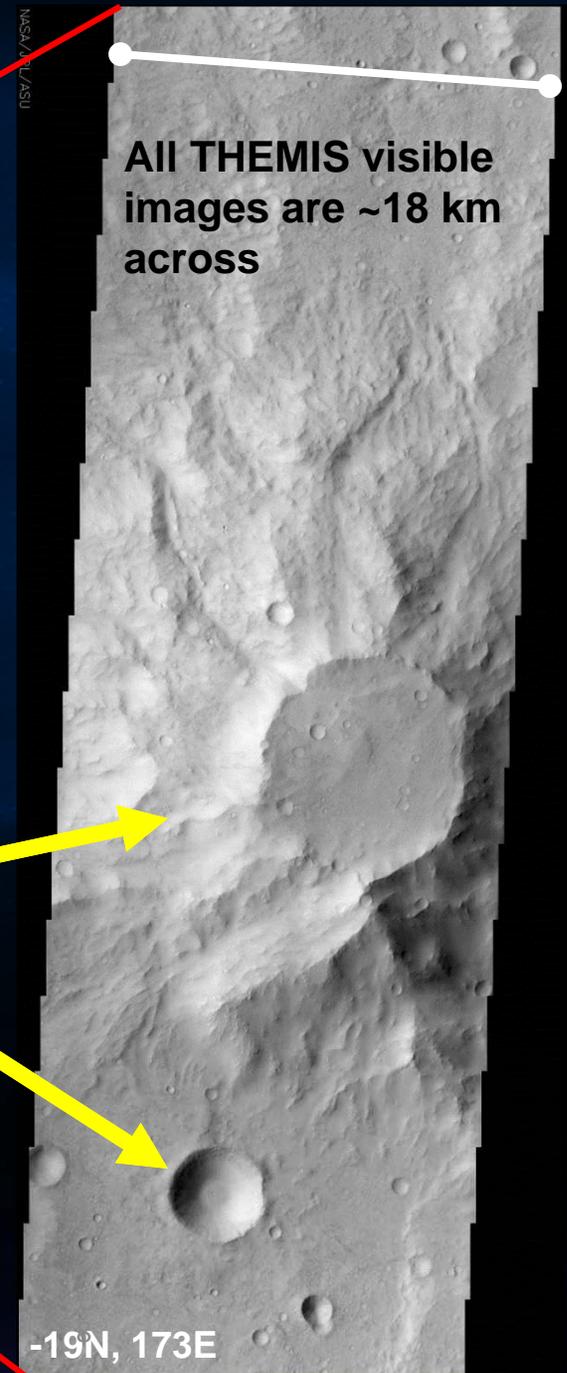
MOLA Shaded Relief Map



THEMIS images are taken during the afternoon and the sun is shining from the left

Sunlit side on left
= raised feature

Shaded side on left
= depression



All THEMIS visible images are ~18 km across

THEMIS Visible Image

-19N, 173E



5 E Learning Cycle

Explore



PART 1: Identify Features on Images of Mars Using a THEMIS Image

National Aeronautics and Space Administration



KAISER CRATER FLOOR
THEMIS VISUAL CAMERA
ODYSSEY SPACECRAFT
 IMAGE ID: V01760004

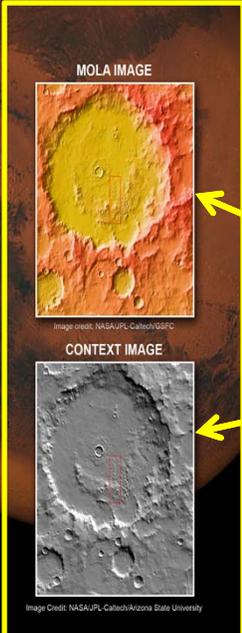
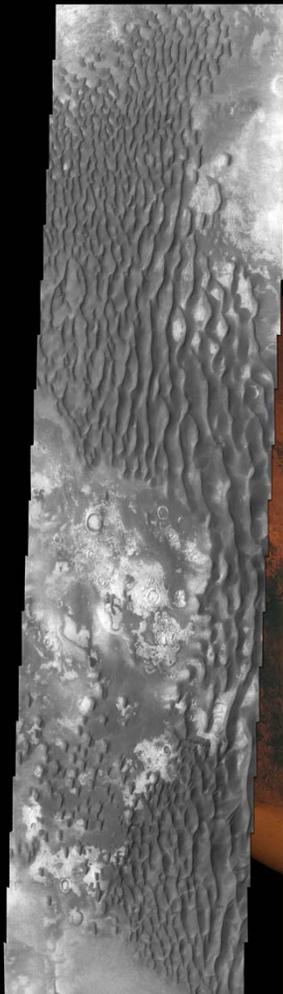
ORBIT: 01760
 VIS IMAGE NUMBER: 004
 CENTER LATITUDE: -48.8 N
 CENTER LONGITUDE: 19.3 E
 SOLAR LONGITUDE: 9.89
 INCIDENCE ANGLE (Max): 68.9
 LOCAL SOLAR TIME (Max): 15.26

Label identified geologic features on both the THEMIS and CONTEXT images. Use Feature ID charts for assistance.

FEATURE ID CHARTS

Image Information

Context Image: MOLA Shaded Relief and Colorized MOLA



Feature	An Example of this Feature	Description of Feature
Canyons		Identified by a deep drop in elevation, canyons are where one side is higher than the other. Canyons with other flow marks are the result of water runoff. The floor of a canyon is generally flat and smooth.
Landforms		Recognized by their shape and size, landforms are the result of erosion. Other features on Mars include craters, ridges, and hills. The shape and size of a landform can be used to identify it.
Layers		Layers of material can be seen in different areas of Mars, including canyon walls. They are formed by the accumulation of sand, silt, and other particles over time.
Fractures/Faults		The result of a break in the surface, fractures are the result of stress. They can be formed by the expansion of the crust and the resulting movement of rock.

Feature	An Example of this Feature	Description of Feature
Channels		Channels are the result of water flow. They are formed by the erosion of the surface by water. Channels can be identified by their shape and size.
Valley Networks		Valley networks are the result of water flow. They are formed by the erosion of the surface by water. Valley networks can be identified by their shape and size.
Unsettled Islands		Unsettled islands are the result of water flow. They are formed by the erosion of the surface by water. Unsettled islands can be identified by their shape and size.
Chaotic Terrain		Chaotic terrain is the result of water flow. It is characterized by a jumble of rock fragments and boulders. Chaotic terrain can be identified by its irregular shape and size.

Feature	An Example of this Feature	Description of Feature
Crater		Craters are the result of an impact. They are formed by the collision of a meteorite or asteroid with the surface. Craters can be identified by their circular shape and size.
Impact Crater		Impact craters are the result of an impact. They are formed by the collision of a meteorite or asteroid with the surface. Impact craters can be identified by their circular shape and size.
Crater Classifications		Craters can be classified into different types based on their size and shape. The most common types are simple, complex, and shield.
Gullies		Gullies are the result of water flow. They are formed by the erosion of the surface by water. Gullies can be identified by their shape and size.

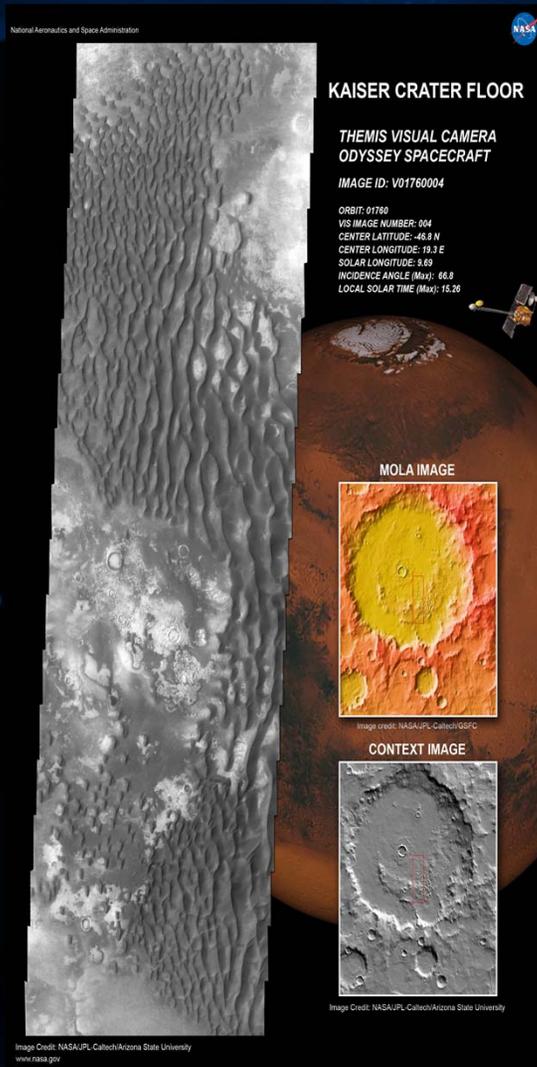
Feature	An Example of this Feature	Description of Feature
Sand Dunes		Sand dunes are the result of wind erosion. They are formed by the accumulation of sand. Sand dunes can be identified by their shape and size.
Dust Devil Tracks		Dust devil tracks are the result of wind erosion. They are formed by the erosion of the surface by dust devils. Dust devil tracks can be identified by their shape and size.
Wind Streaks		Wind streaks are the result of wind erosion. They are formed by the erosion of the surface by wind. Wind streaks can be identified by their shape and size.
Yardangs		Yardangs are the result of wind erosion. They are formed by the erosion of the surface by wind. Yardangs can be identified by their shape and size.

Feature	An Example of this Feature	Description of Feature
Caldera		Calderas are the result of a volcanic eruption. They are formed by the collapse of a volcano. Calderas can be identified by their large size and irregular shape.
Fissures		Fissures are the result of volcanic activity. They are formed by the eruption of a volcano. Fissures can be identified by their shape and size.
Lava Flows		Lava flows are the result of volcanic activity. They are formed by the eruption of a volcano. Lava flows can be identified by their shape and size.
Collapsed Lava Tubes		Collapsed lava tubes are the result of volcanic activity. They are formed by the eruption of a volcano. Collapsed lava tubes can be identified by their shape and size.



5 E Learning Cycle

Explain



- Explain a few of the features you observed and identified in the area.
- What criteria did you use to identify the feature?
- Is it possible it could be a different feature? What other feature could it be?



5 E Learning Cycle

Evaluate



PART 1: Identify Features on Images of Mars

Sample Student Log

Feature Name		Age Rank	Describe How Feature Formed
Dust Devil Tracks	Oldest		
Crater			
Lobate Ejecta			
Central Peak			
	Youngest		



5 E Learning Cycle

Explore

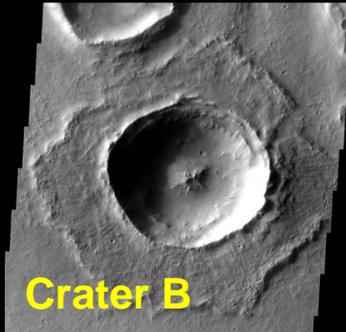
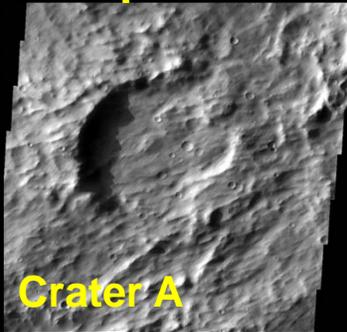


Relative Ages of Features

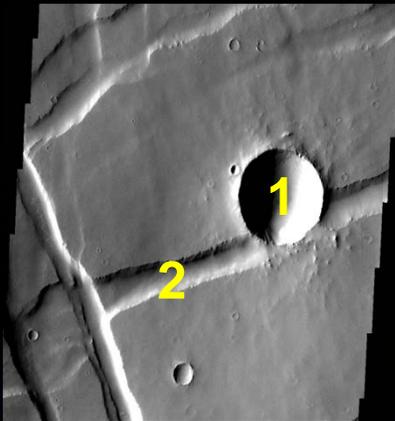
Accessing Prior Knowledge

Discuss the examples below within your group. Be sure you can justify your answers.

Example 1: Which crater is older?

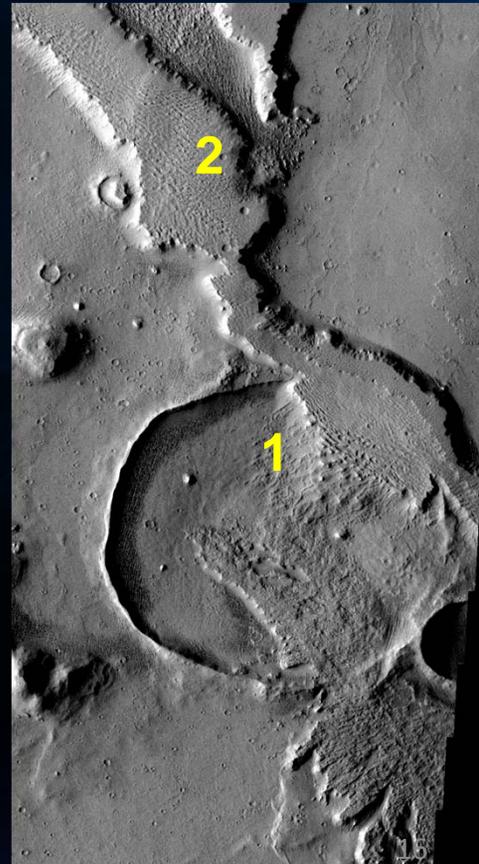


Example 2: Which feature is younger?



Feature 1 = Crater
Feature 2 = Fracture

Example 3: Which feature is younger?



Feature 1 = Crater
Feature 2 = Channel



PART 2: Determine Relative Ages of Features

Identify which features are older or younger using the relative age dating principles:

- Crater Classification
- Principles of Superposition
- Principle of Cross-Cutting Relationships



Relative Age Dating Techniques

RELATIVE AGE DATING TECHNIQUE
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 measure the exact age of a crater on Mars, but we can use these categories to determine its relative age.

I. Preserved Craters

- Have perfect cones
- Flat floors
- Look new
- Can sometimes see impact craters on their sides
- Young craters

II. Modified Craters

- Craters that have been changed or modified by:
 - Erosion (wind)
 - Lava flows
 - Some times to give craters a smooth floor (like a lake)
 - Crater may have smooth floor, partially filled with (lava or sediment)
 - No longer appears to be a crater

III. Drowned Craters

- Look very worn away
- Rims are broken
- Have been severely changed (modified)
- Crater has been filled (partially or completely) by sediments
- Very old craters

RELATIVE AGE DATING TECHNIQUE
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:

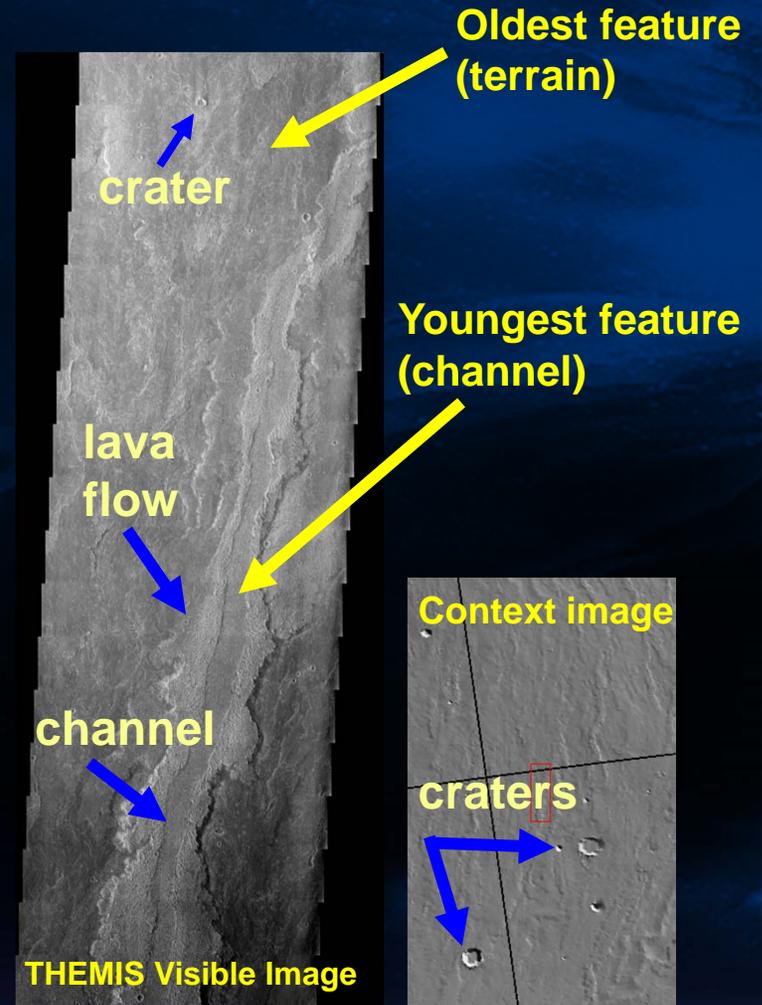
I. Cross-Cutting Relationships:

- A crater (or any other feature) that cuts through another feature is younger than the feature that it cuts through.

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.

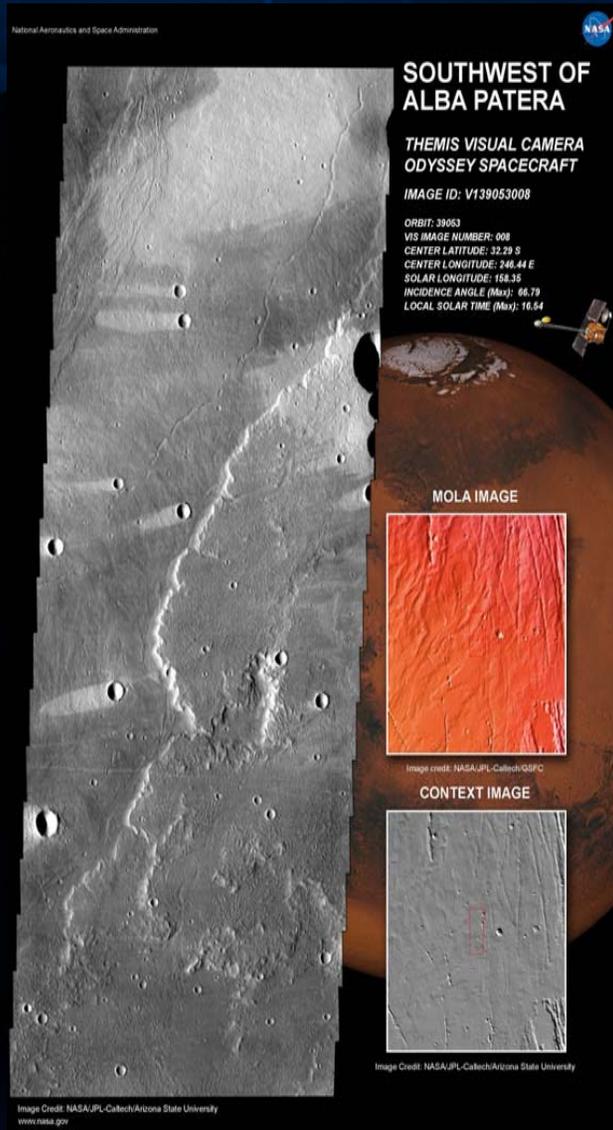
Lava flow is older than the channel but younger than the terrain





5 E Learning Cycle

Explain



- Which features appear to be the youngest?
- Oldest?
- What criteria did you use to identify the age of these features?



5 E Learning Cycle

Evaluate



PART 1: Identify Features on Images of Mars

Sample Student Log

Feature Name		Age Rank	Describe How Feature Formed
Dust Devil Tracks	Oldest	2	The dust devil track crosses over the crater and terrain
Crater		1	Dust devil is on top of the crater
Lobate Ejecta		1	Forms at the same time as a crater
Central Peak		1	Forms at the same time as a crater
	Youngest		



5 E Learning Cycle

Elaborate



5 E Learning Cycle

Explore



PART 3: Calculate Sizes of Features (THEMIS images)

To determine the size of any feature, you must know a standard measurement:

- THEMIS visible images are 18.0 km across

To calculate the size of features on Mars you will:

1. Determine the *scale factor* for your image:

- Measure the distance across in centimeters
- Divide to figure out the scale of your image

$$18.0 \text{ km} = \underline{21.0} \text{ cm}$$

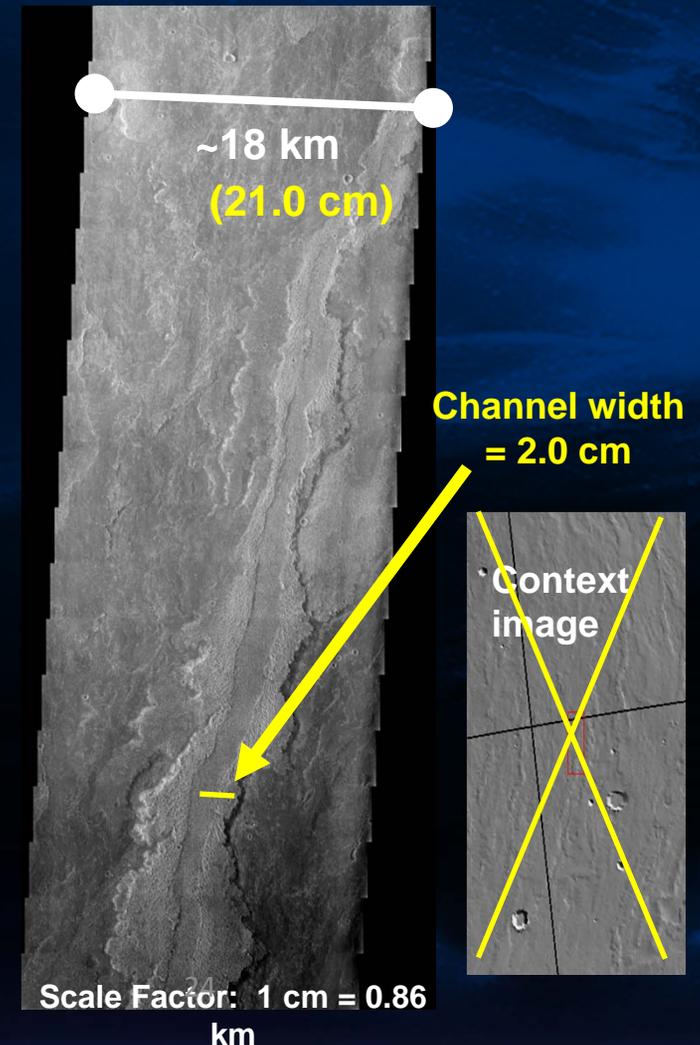
$$18.0 \text{ km} / \underline{21.0} \text{ cm} = \underline{0.86 \text{ km/cm}}$$

$$\text{Scale Factor: } 1.0\text{cm} = \underline{0.86 \text{ Km}}$$

2. Multiply the size of any feature measured in centimeters by the scale factor:

$$\text{Example: Width of channel} = \underline{2.0} \text{ cm}$$

$$\underline{2.0} \text{ cm} \times \underline{0.86 \text{ km}} = \underline{1.72 \text{ km}}$$





PART 3: Sizes of Features (younger students)

Consider the following options for younger students:

1. Measure features in centimeters without calculating the actual size in km.
2. Find features on image that are greater than, less than or equal to general objects you may have in the classroom.
 - a) Pencil Eraser: Example: *This crater is about the size of my pencil eraser.*
 - b) Coins (dimes, nickels, quarters, pennies): Example: *This feature is the length of 10 pennies.*
 - c) Post-its of different sizes: Example: *This feature is the size of two small post-its.*



PART 3: Sizes of Features (Older students)

Calculating Heights and Depths of Features

To do this calculation, students would use the following steps:

EXAMPLE:

1. Measure the width of the shadow in centimeters.
2. Using the calculated scale factor (From *Calculate the Size of Features*), convert the shadow measurement to kilometers.

$$1\text{ cm} \times 0.86\text{ km/cm} = 0.86\text{ km}$$

3. Divide that calculated measurement by the tangent of the incidence angle to compute the depth of the feature being observed.

$$\frac{0.86\text{ km}}{\tan 67.1} = 0.41\text{ km deep crater}$$



5 E Learning Cycle

Explain



National Aeronautics and Space Administration



MAMERS VALLIS

THEMIS VISUAL CAMERA
ODYSSEY SPACECRAFT

IMAGE ID: V05055010

ORBIT: 05055
VIS IMAGE NUMBER: 010
CENTER LATITUDE: 31.29 S
CENTER LONGITUDE: 19.09 E
SOLAR LONGITUDE: 132.4
INCIDENCE ANGLE (Max): 69.7
LOCAL SOLAR TIME (Max): 11.13



Image Credit: NASA/JPL-Caltech/Arizona State University
www.nasa.gov

MOLA IMAGE

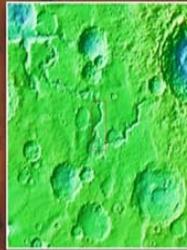


Image credit: NASA/JPL-Caltech/GSFC

CONTEXT IMAGE



Image Credit: NASA/JPL-Caltech/Arizona State University

- What is the width of this feature?
- Where did you measure?
- How many measurements do you think are necessary?



5 E Learning Cycle

Evaluate



PART 3: Calculate Sizes of Features

Feature Name	Feature Measurement	X	Scale Factor	= Feature Actual Size
Dust Devil Tracks	3.7 cm		0.86 km/cm	3.2 km
Crater	6.9 cm		0.86 km/cm	5.9 km
Lobate Ejecta	2.7 cm		0.86 km/cm	2.3 km
Central Peak	0.5 cm		0.86 km/cm	0.4 km