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Ages on Mars

Martian Surface Age Exploration

You have now learned some very important things about various planets and moons in our Solar System. You have also learned important specific details about the planet Mars from the expert's presentation. We now want to discovery important information about various aspects of the Martian surface.

Here is a summary of what was discussed in the Mars presentation.

- Mars has a very thin atmosphere which is about 1000 times thinner than the Earth's atmosphere
- There is no liquid water on the surface of Mars today due to the fact that the atmosphere is to thin to allow liquid water to remain stable
- Mars has polar ice caps which are made of dry ice (CO_2) and water ice (H_2O)
- Mars has a very large bulge know as the Tharsis Bulge, which was lifted up by geologic activity
- On the Tharsis Bulge are many volcanoes the biggest of which is Olympus Mons.
- Valles Marineris is an enormous canyon which is a tear in the Martian crust probably related to the rise of the Tharsis Bulge
- There is evidence of dried river beds on the surface of Mars indicating that some time in the past Mars did have liquid water on its surface.
- There are two types of dried river beds: The outflow regions near volcanic regions and tributary systems found in the more mountainous regions of Mars

We have been working with the density of impact craters in order to use them density of craters to tell us something about the age of the surface. In this lesson we will do more than just saying one area is older than another area. We will actually determine the age in years of different surfaces on Mars.

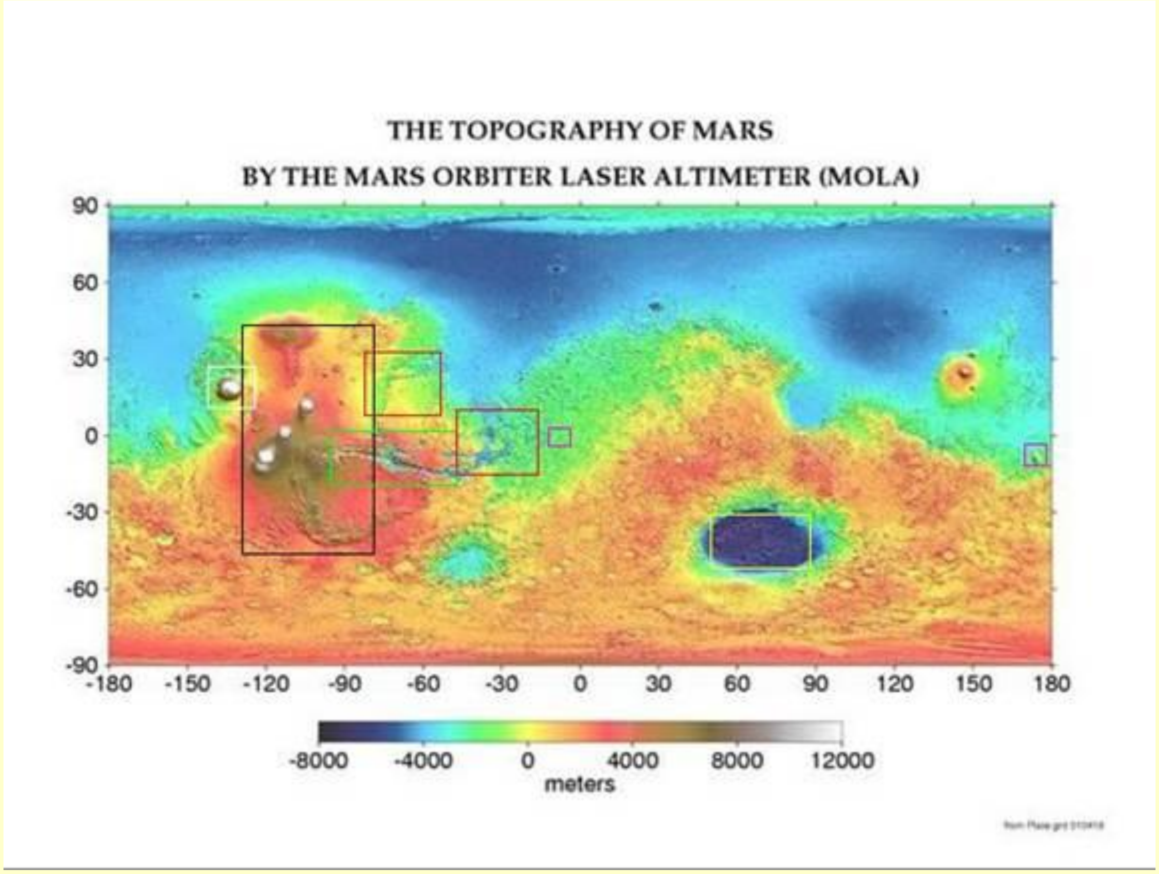
Given that we can use crater density to determine the age of a surface think about some questions about age that you might want answered from the summary list above. Come up with two "when" questions that you might like answered and write them out.

There are also very important connections that can be drawn between different types of geologic activity on Mars. For instance did the rise of the Tharsis Bulge create Valles Maineris, or did volcanic activity near the Tharsis bulge cause underground ice to melt which broke out onto the surface to create the large outflow regions. Although these are interesting conjectures, in order for a connection to be possible it must pass the "cause and effect" test. Here is an example:

Suppose that you are out of town for the entire month of July. You are growing a nice pumpkin plant so that you will have pumpkins for Halloween. When you leave on July 1st, the planet is doing very well. On July 10th your grandmother, who has been watching your house calls and reports some bad news. You pumpkin plant has somehow been destroyed, crushed to the ground and completely torn apart. When you return on July 31st you find out that there was a terrible hail storm that hit town while you were gone. You think that may be it was the terrible hail storm that destroyed your pumpkin plant.

This is a very good conjecture. What would you need to know in order to test how viable is your conjecture? Write out your answer. Include in your discussion what would prove that hail had nothing to do with the destruction of your plant. Also discuss whether your findings prove that hail was the culprit.

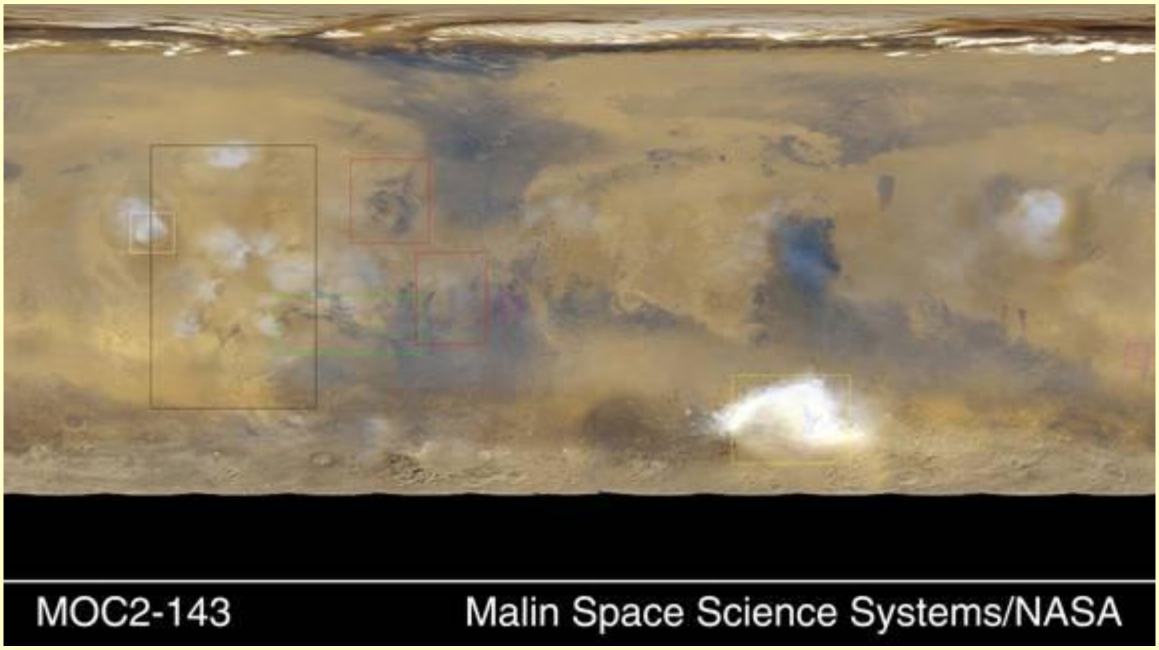
Now consider Mars. If you think that one event on Mars might have caused a second event, what has to be true about the time of the two events in order for your conjecture to be possibly true? Explain.



Black – Tharsis Bulge Region
Green – Valles Marineris
Red – Outflow Regions (Dried River Beds)
White – Olympus Mons
Purple – Meridiani Planum (Opportunity landing site near Longitude = 0)
Purple – Gusev Crater (Spirit landing Site near Longitude = 180)
Yellow – Hellas Crater

Above are some of the interesting sites on Mars. Martian Longitude is along the bottom and Latitude is on the y-axis. This is a topographical map which shows the highest elevations in white and the lowest points in dark blue. The color scale below the map shows the elevation.

Here is a real image of Mars with the same regions marked.



In this image you can see clouds in the atmosphere of Mars. They tend to form over the high volcanic peaks on the Tharsis Bulge and over the Hellas crater.

Examine the topographical map and the Mars image closely in order to see the areas of interest.

Dating a region on Mars (Example exercise)

To conduct our age dating we will use data from the high-resolution Mars Orbiter Camera (MOC) which is on the Mars Global Surveyor satellite in orbit around Mars. There are over 200,000 available MOC images to analyze at the Malin Space Sciences Systems website.

On your web browser enter the URL:

www.msss.com

This is the Malin home page. Scroll down and click on the link under the Mars Global Surveyor which says “MOC Gallery - Over 212,000 Images”

On this page there are many links in the box wit the title:

MOC Narrow Angle Images
High Resolution Images and their Context

These links are different dates when the images were taken. For this practice exercise we will click on the link entitled:

E13 through E18
February 2002 - July 2002

After clicking on this link take a long look at the image of the entire surface of Mars. Can you find a few big features? Try to find Valles Marineris, The Tharsis Bulge, Olympus Mons, Hellas Crater and the Outflow regions.

Before continuing, show your teacher that you have located some of these features.

The white line that runs horizontally across the middle of the images is the Martian Equator. It is the white line that is just above Valles Marineris.

Is Valles Marineris in the Northern or Southern Hemisphere of Mars? Explain.

What about Olympus Mons?

The white line that runs vertically through the middle of the image is the 0 degree longitude line. The longitude just to the left of this line is 1 degree West. The longitude just to the right is 359 degrees West.

We are going to analyze an image that has coordinates:

Longitude = 36.61 degrees West
Latitude = 17.01 degrees North

Try to figure out which small white box is the correct one. Then click on the box.

Did you get the click the right box? Here is how to tell. The new image that appears shows the range in latitude (up and down) and longitude (right to left). Does the above coordinate fall within these limits? If yes, you are good to go. If no, then hit the back button on the browser and try again.

Once you have found the correct image we need to locate the high-resolution image that we want to analyze. The small green lines show the location of the different images. You should try to estimate which green line is the correct one for the coordinates that we are looking for. When you place the mouse arrow over the green line, it turns into a hand with a finger pointing. At the bottom of the page it will tell you the name of the image.
We are looking for

E1301267
If you need assistance finding this image, ask your teacher for help.

Example Question: When did large amounts of water last flow in the outflow channel?

Before clicking on the high resolution image take a moment to look carefully at the outflow regions in the image. Look at the bottom left portion of the image. You can see various dried riverbeds stretching along and going around giant craters. These beds are very big and deep. At some point water cut these channels in the surface of Mars.

Now image a surface before water started running. There would be many craters uniformly spread across the surface. After the water eroded away the surface and cut a deep channel, what would you expect to have happened to the small craters where the channel now is located?

When the water stopped flowing and the river dried up, craters could begin hitting the channel. How does this compare to the highlands and the maria on the Moon. Why did the maria have so few craters? Explain this and relate it to the craters that we might find today in the dried river beds.

Look where the high resolution image, E1301267, is located. Why did I pick this image as an example? What can we tell by looking at the craters in this image?

Now click on the image E1301267. The link will open up the narrow-angle image. This is the high resolution image we will be analyzing. The right image shows a blow-up of the area with the narrow-angle image shown as a white box superimposed on the image.

Scroll down and at the bottom is some important data for you to record. Record the following information (Be sure to include the units of measure for each):

Image ID (picno):

Longitude of image center:

Latitude of image center:

Scaled pixel width:

Scaled image width:

Scaled image height:

Now you are ready to open E1301267. Click on the link that says:

View full-size image, processed but NOT map-projected
(lossless GIF, best quality, slow download)

You should see a long stripe appear on your screen. You can click on the strip and magnify it so you can see all the details of the image. Because this is a magnified view you will have to scroll around in the browser to see the whole thing.

Remember, this is the bottom of the dried up river channel that is cut deep into the surface of Mars. Clearly there are lots of craters throughout this image. When did these craters form? Before the channel was cut or after? Explain.

Saving and Analyzing the Image

Now you should save this image to your computer desktop. At the top of the browser window go into “File” and select “Save page as…” You can just keep the same name for the image and save it to your desktop. After you have done this you can minimize your browser window.

We now want to count craters in the image. We will do this by using the program “Paint”. Right click on the image and click on “Open with…” when the next menu opens click on “Paint”. The image will now open up in Paint.

On the left hand menu you will see various icons. Click on the that looks like a magnifying glass. Choose 2x which will make the image 2x bigger.

Next choose the pencil icon. This will allow you to draw on the image BUT don’t do that just yet. Move the pencil around on the image. You will notice that near the bottom of the image there will be two numbers that appear and change as you move the pencil around. The image is made up of millions of tiny dots called picture elements. We refer to these as pixels. Here is an example of what you might see: 123,138 This is a coordinate on the image. The first number tells you your x-direction and the second your y-direction.

Spend a little time and see if you can find this coordinate: 1,1

Did you find it? Where in the image is 1,1 located?

We are now almost ready to begin counting craters. In the previous lesson where we compared crater density for several images on Mars, we only counted the craters that had a diameter of 50 meters or bigger. We want to do that again this time using Paint.

Look back at the data you wrote down from the Malin website. Find:

Scaled pixel width:

Here you should have written: 6.24 meters.

This number is telling you the width of each pixel in meters. This means that every single tiny pixel in the image has a width of 6.24 meters. Stop for a moment a think about this. Grab a meter stick and measure out 6.24 meters in order to get a feel for how big it is. Can you do this inside of your classroom? This may seem rather big but remember that the MOC image is taken from a satellite orbiting about 400 km above the surface of Mars.

If each pixel is 6.24 meters, how many pixels, lined up in a row, will give you something that is 50 meters long in the image? Do this calculation and show your work.

If you want to count all the craters that are 50 meters across of bigger, how many pixels across will the crater need to be?

Check with your teacher before continuing.

Now you are ready to begin. We do not want to count all the 50 meter and bigger craters in the entire image. That would take to long. You should be on 2x magnification at this point. You can scroll around the image to wherever you like, but when you decide on a region to measure don't scroll anymore. Just use that sub-region to count your craters.

Use the pencil in Paint and see what the coordinates on one side of a crater is and then what the coordinates are on the other side. Is the first crater you picked 8 pixels across or bigger?

The best way to do this to just move in one direction, say the x-direction. Here is an example:

I have a crater that has a pixel coordinate of 12:44 on the left side. Moving in the x-direction to the right side of the crater I get a new coordinate of 26:44. So in the x-direction I moved
26 pixels - 12 pixels = 14 pixels.

Since this number is greater than 8 pixels, the crater is larger than 50 meters. I want to count it. I now take the pencil in Paint and hold the left mouse button and circle that crater.

Continue until all the craters 50 meters or bigger have a circle around them. **NOTE:** Once you begin to see how big a 50 meter crater is, you don't have to measure craters that are obviously much bigger or much smaller than 8 pixels. You can just circle the obvious ones.

When you are happy with your circled craters, count them up. How many 50 meter and larger craters did you get?

Now we want to get a crater density. In paint measure how many pixels across the image there are and how many pixels down the image. Be careful here. Think carefully how you can find the number of pixels across and down in your sub-image.

Write out the number of pixels across the image and the number down the image.

Now convert these pixel values into actual distance across and down the image. (HINT: use your 6.24 meters for every pixel to do this)

Now compute the crater density for your sub-image. Show your work.

Assigning an Age

After all of the work that you have done, we are now at the point where we can finally reach our ultimate goal: Finding the age of the surface in the bottom of the dried river bed.

To do this we will use something called a calibration graph. Our Mars calibration graph was made using data on crater densities from the moon, and actual surface ages for those areas that were determined from the rocks that the Apollo astronauts brought back from their missions on the Moon. The age of the rocks were found using a method called radiometric dating. This technique tells us how it has been since the rock formed. It therefore gives us a very good measurement of the age of a surface on the Moon.

These measurements are then compared to the crater density, which is found the same way you just found crater density in your sub-region on Mars. The calibration graph had to be modified from the Moon data to the Mars because Mars is closer to the asteroid belt and gets hit by more meteors than the Moon does. Also Mars is bigger than the Moon so its gravity is stronger and effects the number of meteor impacts.

Download the Mars calibration file to your desktop. Right click on the file and open it with Paint.

Look carefully at the x and y-axis. What are each labeled? What does Age (Billion of Years) mean?

The curve on the graph is the function that shows how the crater density is related to the actual age of the surface. Use your knowledge of crater density and relative age to see if this calibration curve makes sense. In other words, when a surface is very old, what is the crater density like? When a surface is very young, what is the crater density like. Discuss your thoughts on whether this calibration graph makes sense to you or not.

For our dried river bed, which axis of the graph do we know and which one are we trying to find out?

Now in Paint, click on the line icon which is right below the blue paint can icon. This will allow you to make a line across the graph. Use the crater density that you found for the dried river bed and draw a horizontal line from that number on the y-axis all the way across to the other side of the graph. Be sure the line is completely horizontal.

You should find that your horizontal line crosses over the calibration line at some point. Go from that cross-over point and draw a new line that is vertical all the way down to the x-axis. What does this new line tell you?

Record the age of the dried river bed.

Concluding Thoughts

Compare the values that all the groups in your class got for the age of the dried river bed. List some of the reasons that each group got different values.

When doing this type of research what is important so that you get consistent answers?

Now use the entire class values to answer this question. How long ago was it when large quantities of water last flowed in this dried river bed? For a really meaningful answer you should figure out the best answer for the class but also take into account the spread in answers. This tells how certain you are about the final age.

Now suppose that you want to know how long ago it was since large quantities of water existed on the Martian surface. What would you have to do in order to make a more general statement about this date?

Project Work

Now that we have completed this example exercise you are free to explore the age of any surface you like on Mars. Would you like to try to figure out the last time there was a major eruption on Olympus Mons? How old is the deepest part of Valles Marineris? What about the Spirit and Opportunity sites. Both Mars landers found evidence that water use to exist at there landing sites. Maybe you are interested in when this was. You can explore the Meridiani Planum (longitude = 6 degrees W, Latitude = 2 degrees S.) or the Gusev crater (Longitude = 184 degrees W, Latitude = 14 degrees S.)

Just pick your site carefully and be sure to enjoy yourself. You should also record all your data and save your Paint image with circles around craters and your final calibration graph. You will then compare ages of various features and try to determine an "cause and effect" relationship between different processes on Mars.