

ASTR 310 Tutorial 4: Craters

When a meteorite hits the surface of a planet or moon, it creates an impact crater. This picture of our Moon's Mare Nubium and surrounding hills shows some of the Moon's surface is quite smooth while other regions are covered in craters.

By measuring the sizes and number of craters, astronomers can learn about the objects (called the “impactors”) that struck the surface and also about the ages of various regions on the planet’s surface.



The Mare Nubium on the Moon

Part 1: What Should We Measure?

From what you observed when you made craters in the bucket of sand, write down as many factors as possible:

The appearance of a crater depends on these factors

Characteristics that describe a crater

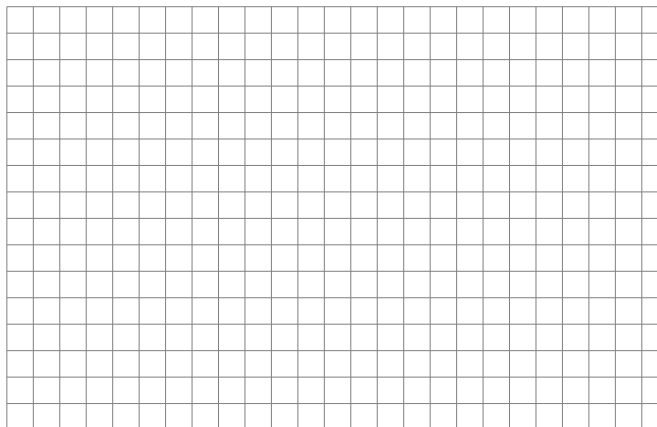
Part 2: Explore, Discover and Predict

The appearance of a crater depends on many factors. Here, you will use steel ball bearings dropped from a constant height. Make craters with each ball bearing at least 2 times to get a more accurate result. Each time, measure the diameter of the crater and record your results.

Goal: Use the data to make 2 graphs that you can use to make predictions about the size of a crater that would form by dropping a certain steel ball bearing.

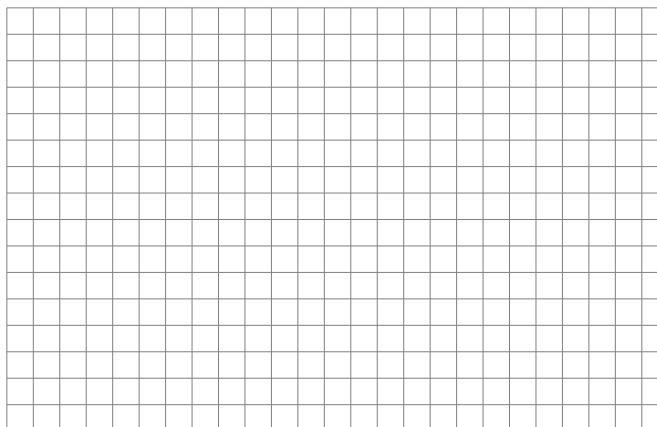
Drop height:		
Ball Bearing		Crater
Diameter	Mass	Diameter

Crater diameter



Ball-bearing diameter

Crater diameter



Ball-bearing mass

Based on your graphs, what is the diameter of the crater that forms when you drop a steel ball bearing with diameter 12.7 mm and mass 8.4 g into the sand from the same height you dropped the other ball bearings? Record your predictions in boxes below and then **show them to your TA**.

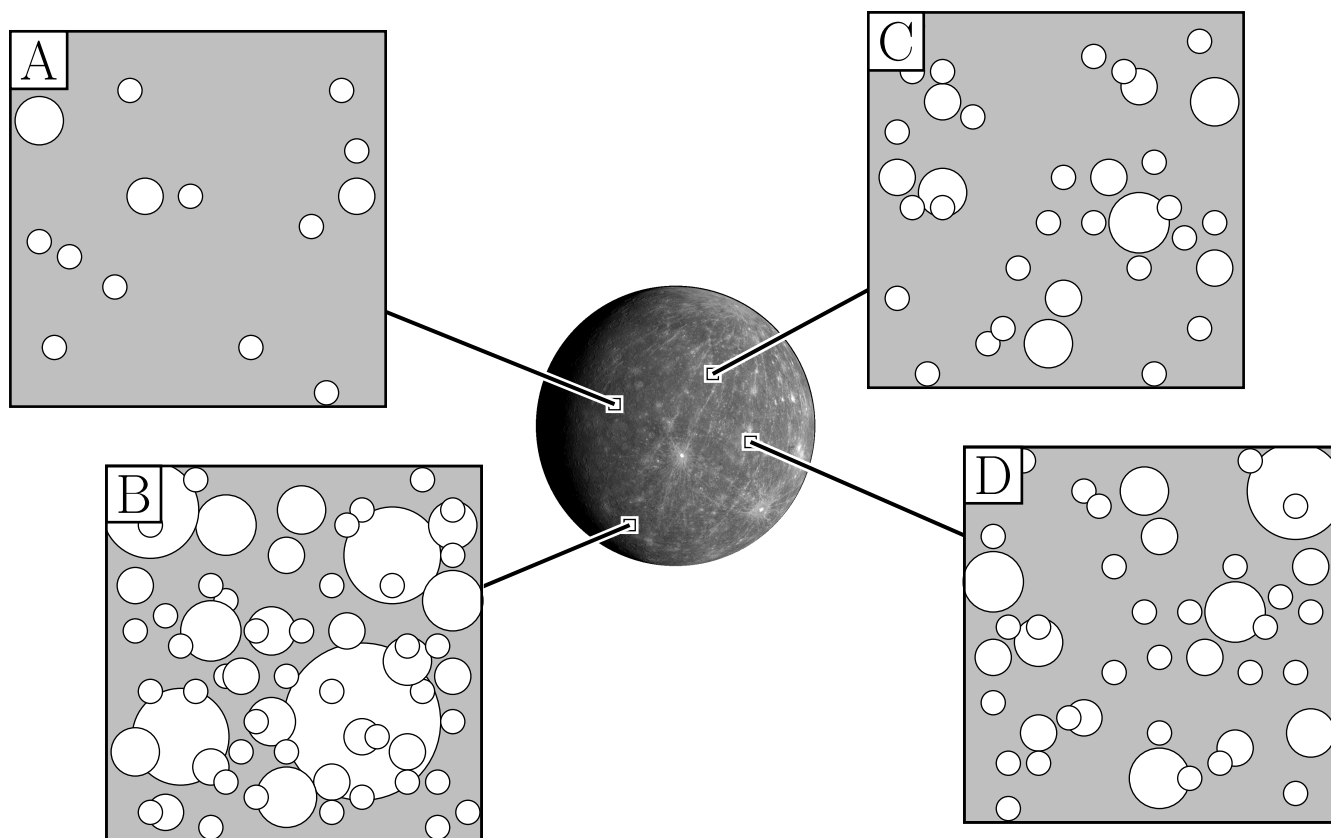
prediction from diameter <i>vs</i> diameter	prediction from diameter <i>vs</i> mass
best prediction	

results

Part 3: Surface Chronology

Impactors have been hitting the planets and moons in the Solar System since they formed 4.5 billion years ago. Volcanoes, floods, weather and other geophysical processes that smooth out the surfaces have erased some of those craters, though. By counting the number of craters in a region of a planet or moon, astronomers can estimate the age of the surface: how long craters have been forming on the surface since it was last smoothed out.

Four different regions of the same planet, as they appear today, are shown in the pictures below. Only craters larger than 1 km are shown.

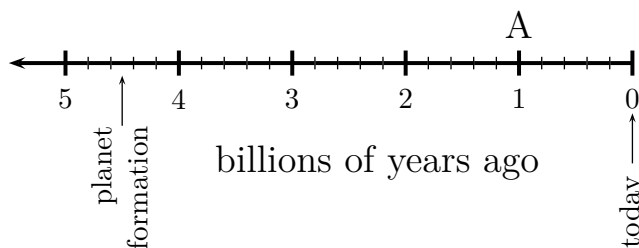


Write the letters **A, B, C, D** in the boxes below to arrange the four surfaces from oldest to youngest.

oldest youngest

Assume for this planet impactors hit regions the size of those shown above at a constant rate of 14 impacts per billion years. In reality, the impact rate is not constant and this assumption is false but we can still use it to estimate the ages of different regions.

This time line runs from today (time 0) back into the past to planet formation (4.5 billion years ago.) **Write the letters A, B, C, D** on this time axis at the locations which show their ages. For example, surface A has only 14 craters, so it is 1 billion years old.



Part 4: Questions Please hand in this worksheet to your TA when you're done.

1. Copy your crater diameter data from Part 2 into this Table. Then calculate the ratio of the crater diameter to the impactor diameter.

You should find the ratio is about the same for all ball bearings. Approximately what is the ratio? _____

Talk to a group who dropped the ball bearing from the other height, either 0.5 m or 2.0 m. What is their ratio? _____

Crater Diameter (mm)	Impactor Diameter (mm)	Ratio: $\left(\frac{\text{Crater Diameter}}{\text{Impactor Diameter}} \right)$
	4.8	
	6.4	
	8.7	
	12.7	
	19.0	
	25.4	

How do you think the ratio will change if you drop the ball bearings from an even greater height?

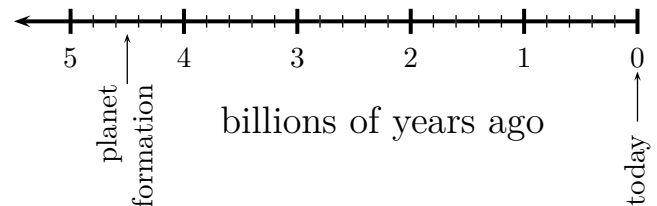
smaller ratio no change larger ratio

2. Two rocks, *a* and *b*, hit the Moon and form craters. The rocks are made of the same material and hit the surface at the same speed but the diameter of rock *b* is 2 times larger than the diameter of rock *a*. What can you say about the craters formed by these two rocks? Check one:

- ☐ crater *b* is about 8 times wider than crater *a*
☐ crater *b* is about 4 times wider than crater *a*
☐ crater *b* is about 2 times wider than crater *a*
☐ crater *b* is about $\sqrt{2}$ times wider than crater *a*

3. Copy your chronology from Part 3 onto this time axis.

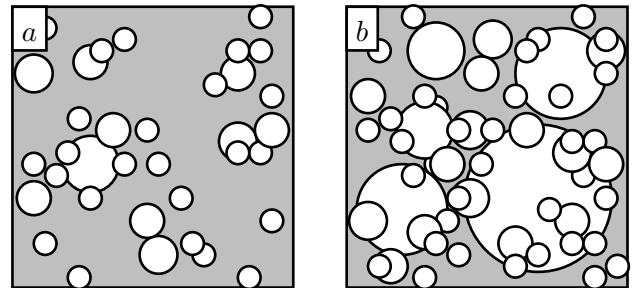
Over what **interval of time** (from when to when) did the impact craters in Region C form?



Suppose it was a flood that smoothed out Region C. When did that flood occur?

4. The pictures show two cratered regions, *a* and *b*, of the same size on the planet Mercury.

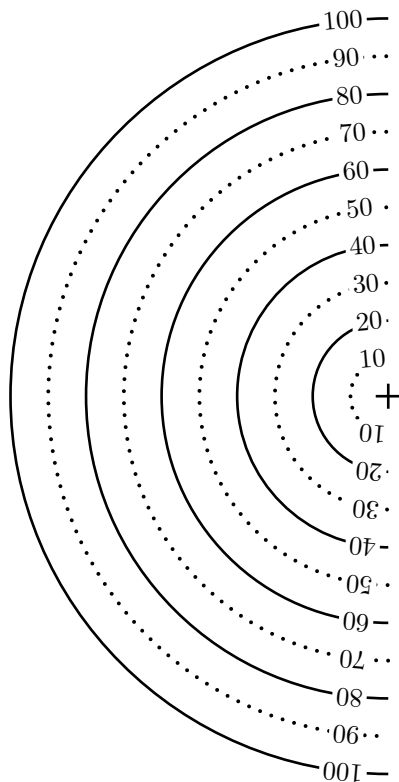
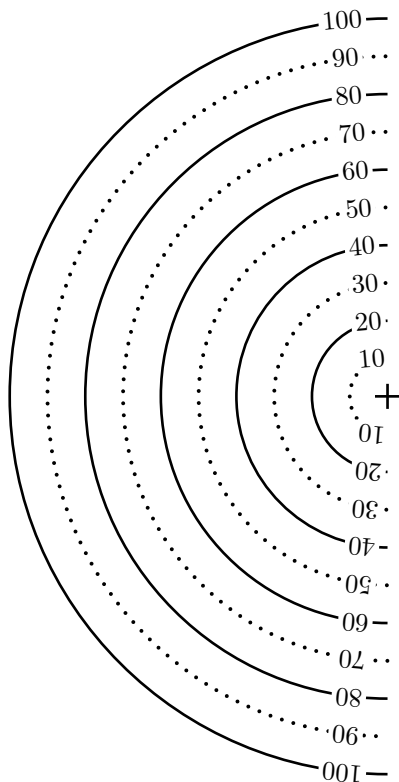
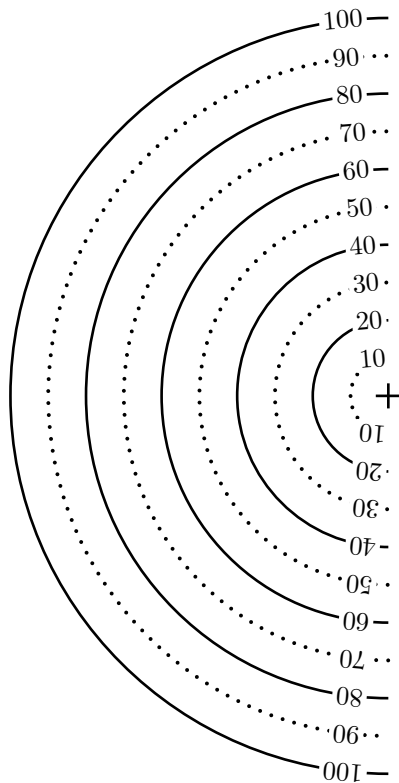
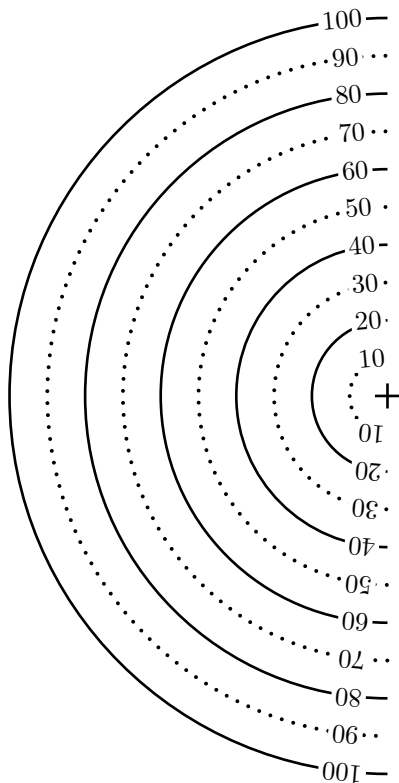
What can you tell about the relative ages of the surfaces of the two regions? Check one:

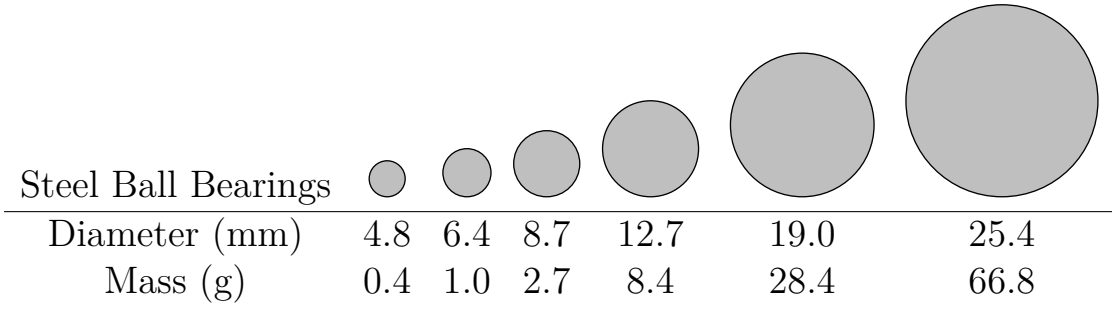
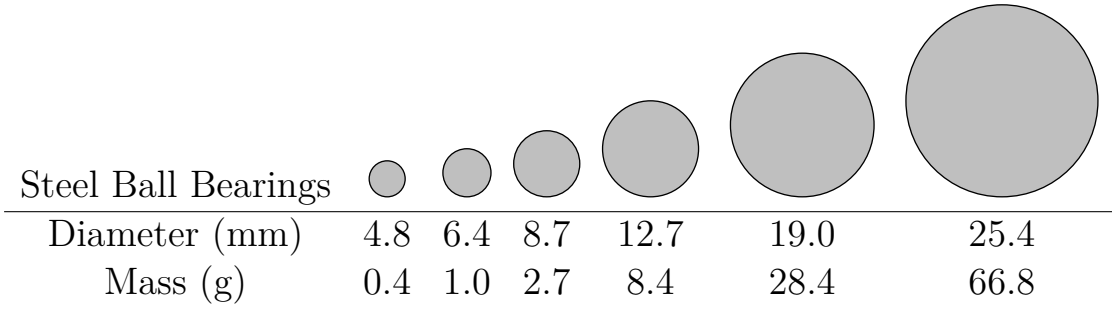
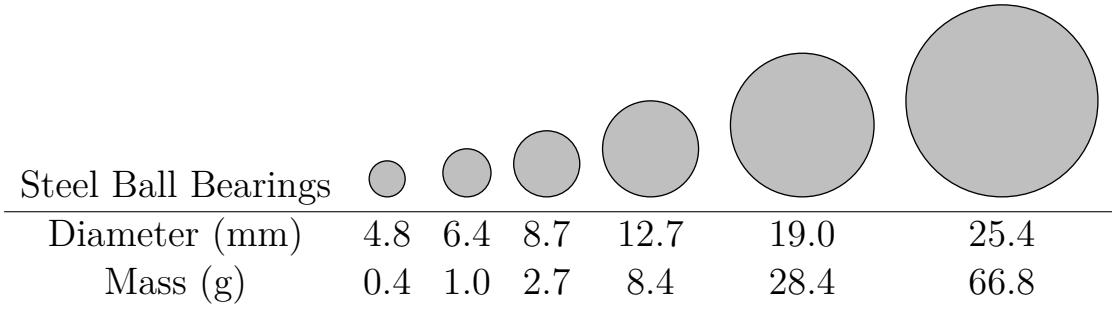
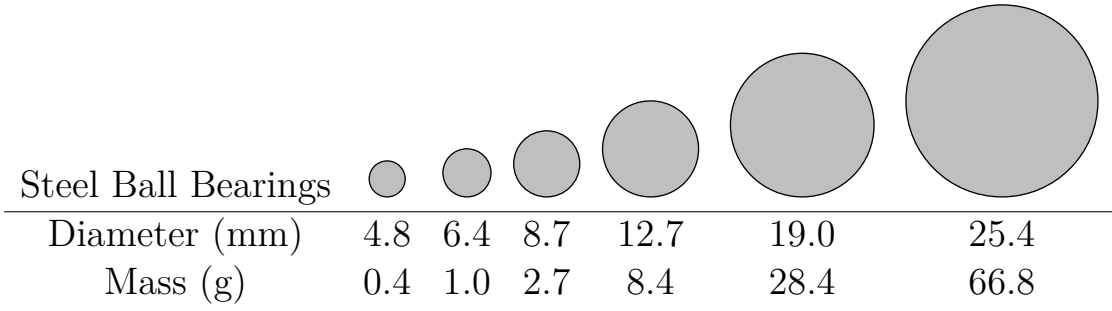
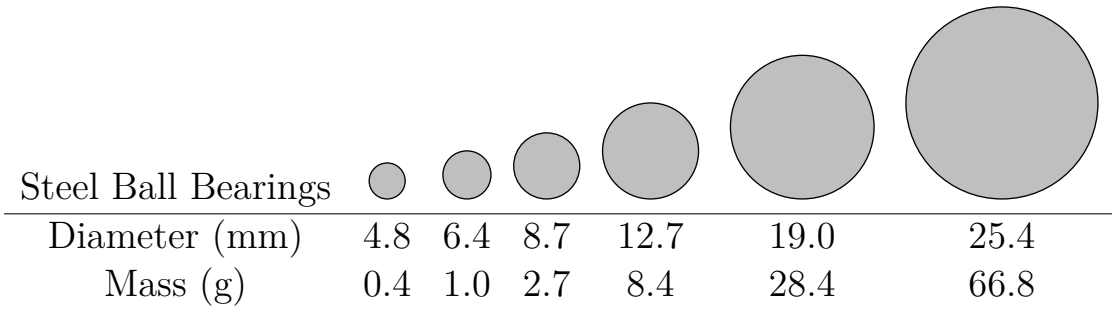


- ☐ surface *a* is younger than surface *b* because surface *a* has had recent floods or volcanic eruptions
☐ surface *a* and surface *b* are the same age, the age of Mercury
☐ surface *a* is older than surface *b* because surface *a* has had many floods and/or volcanic eruptions
☐ surface *a* shows a region of Mercury that receives less impacts than surface *b* so you can't tell from these pictures which surface is older

The appearance of a crater depends on these factors:

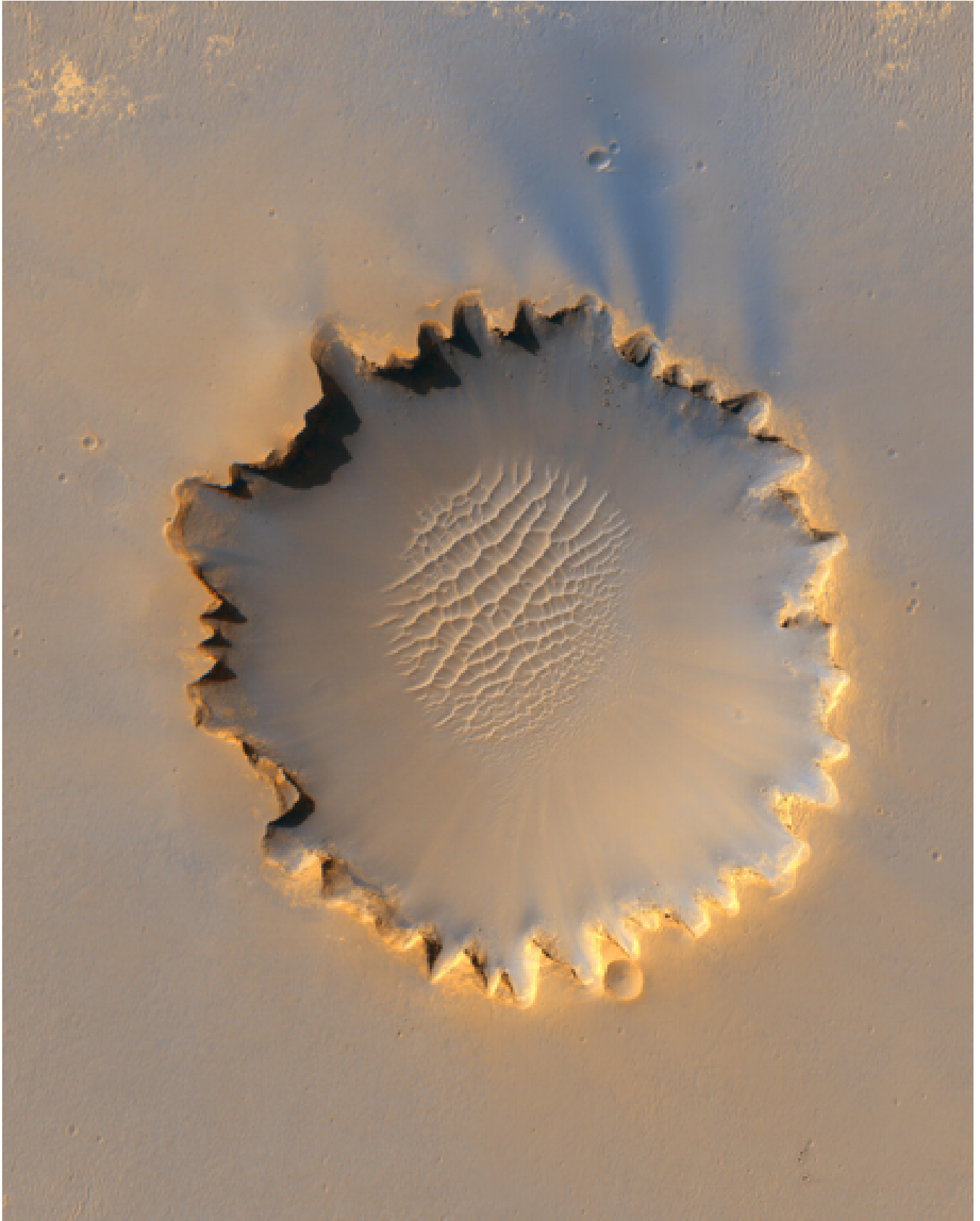
Characteristics that describe a crater:







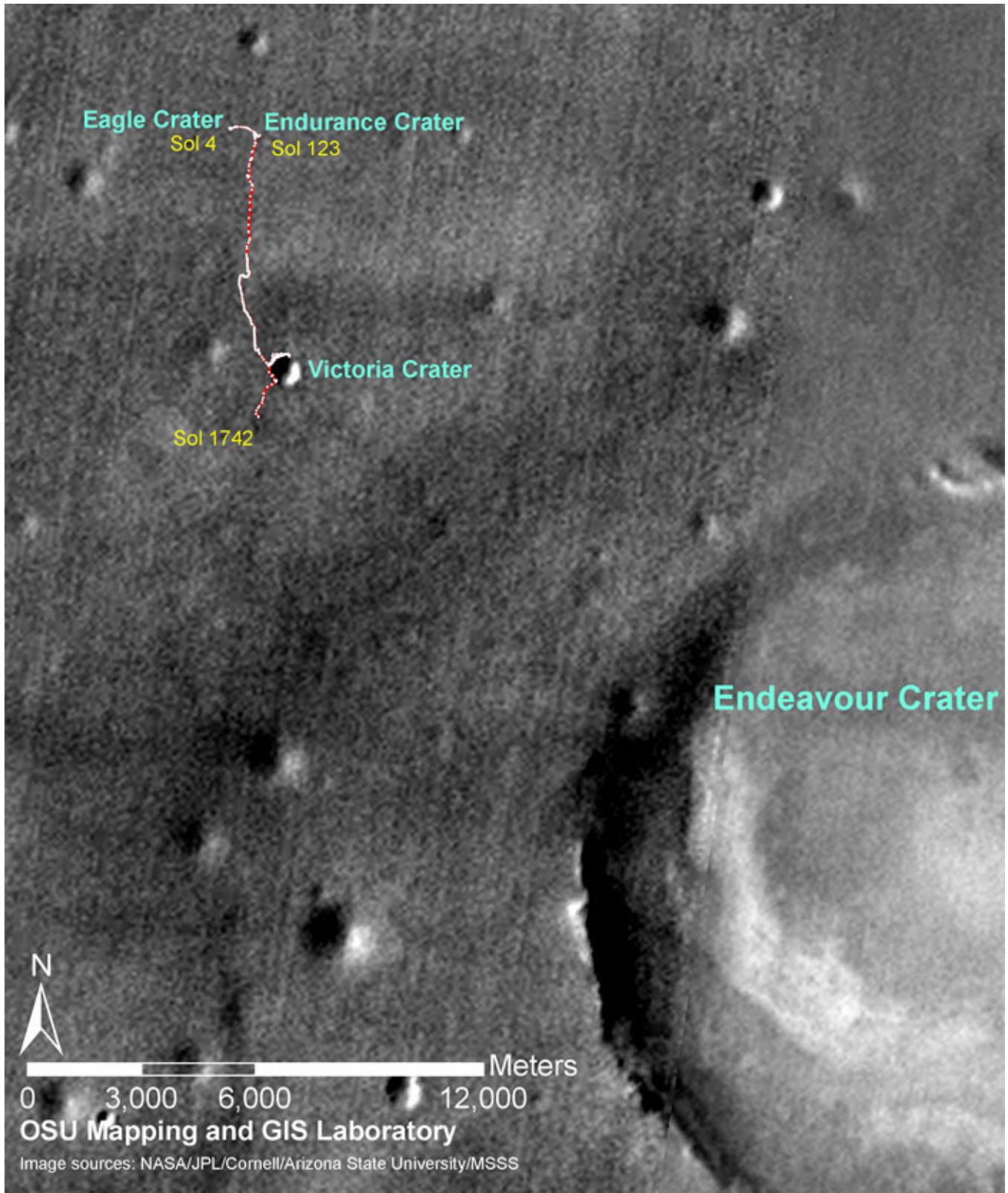
Mare Nubium and surrounding hills on the Moon



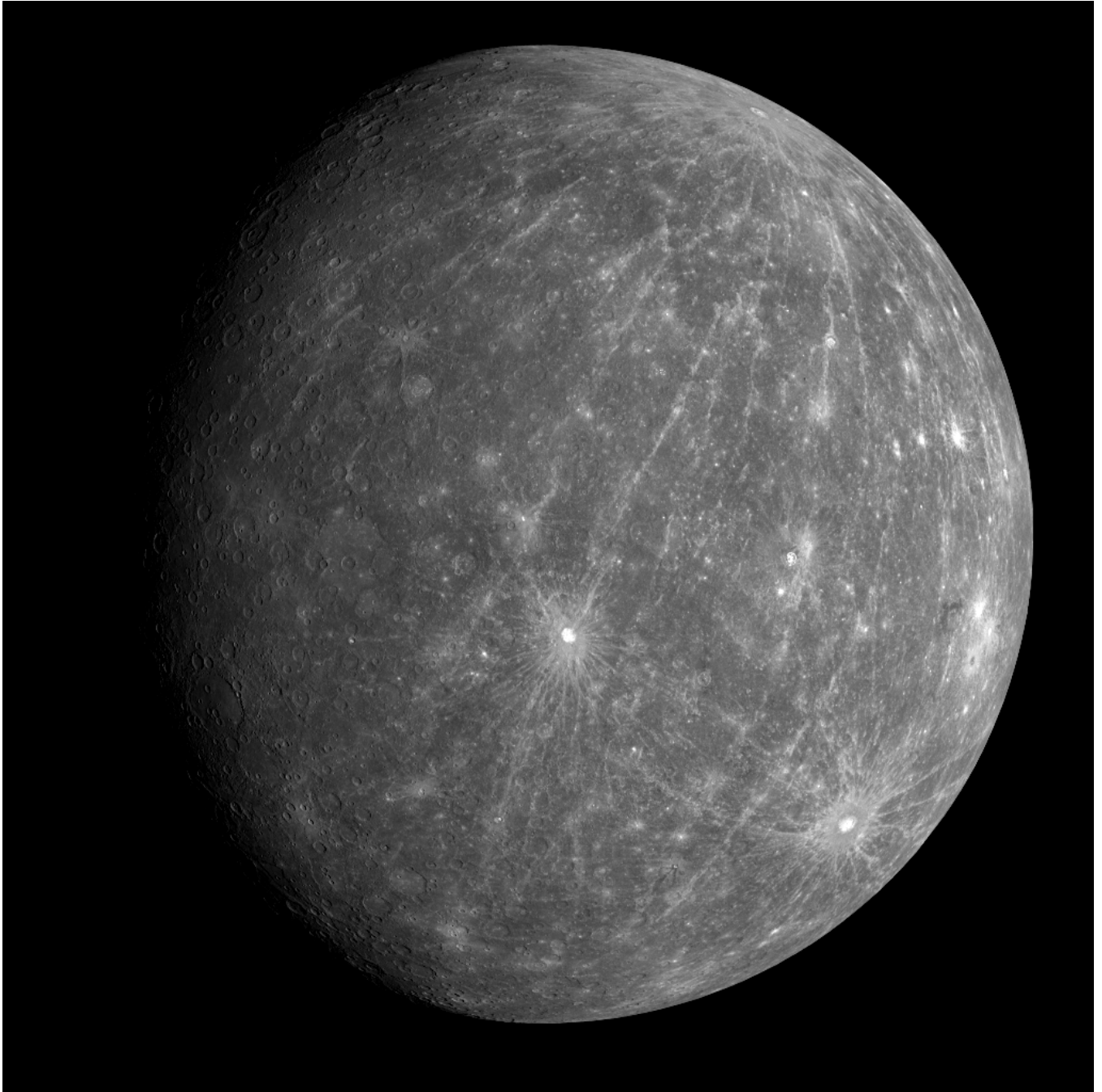
Victoria Crater, Mars



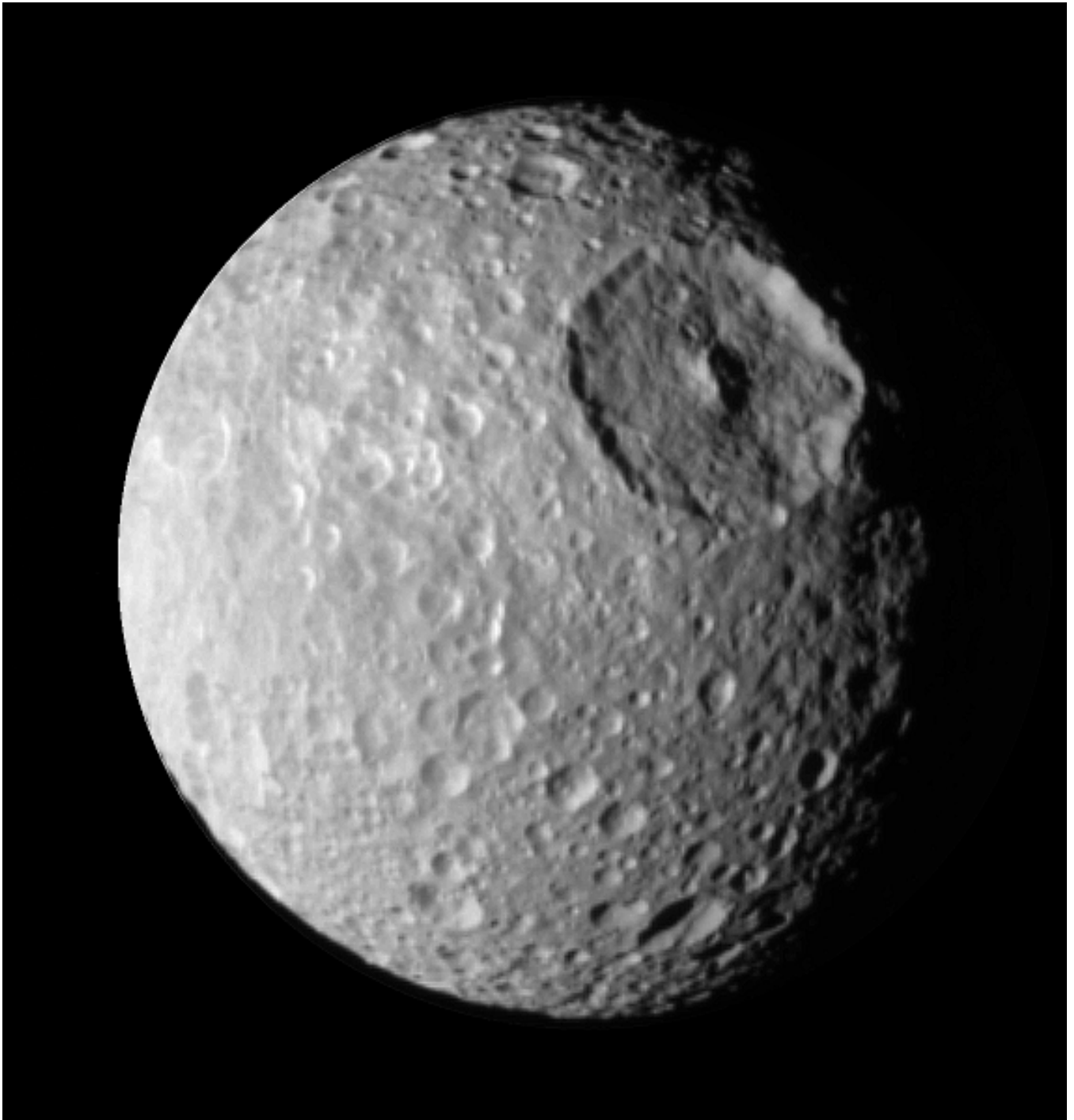
Mars Rover *Opportunity*



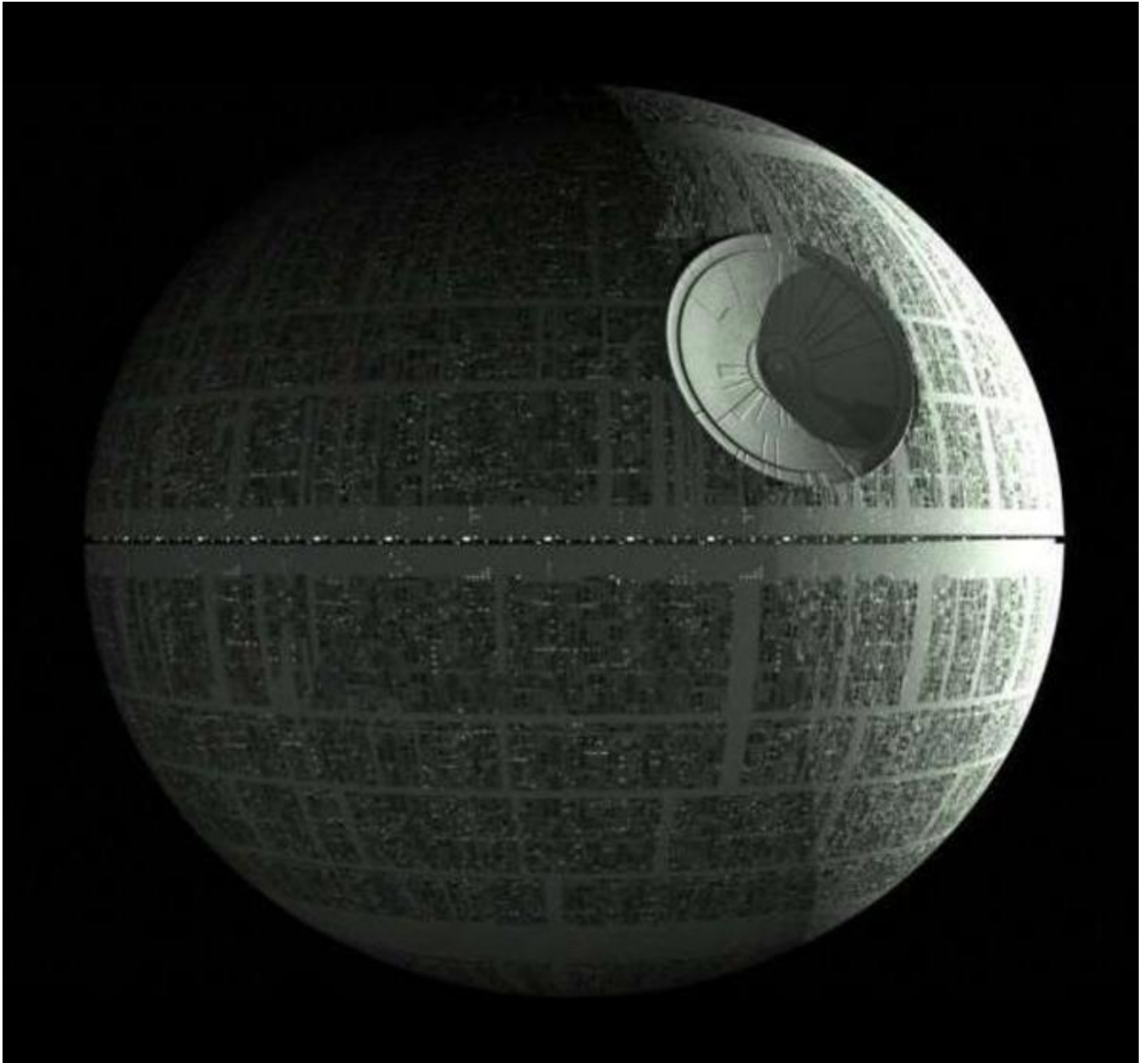
Eagle, Endurance, Victoria and Endeavour craters on Mars



Mercury



Saturn's moon Mimas



That's no moon. It's a space station...



Barringer Crater, Arizona