

# Today

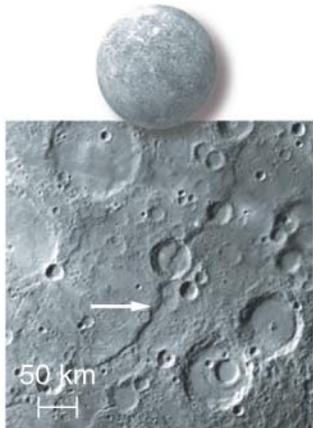
- Terrestrial Planet Geology

# Events

- Spring break next week

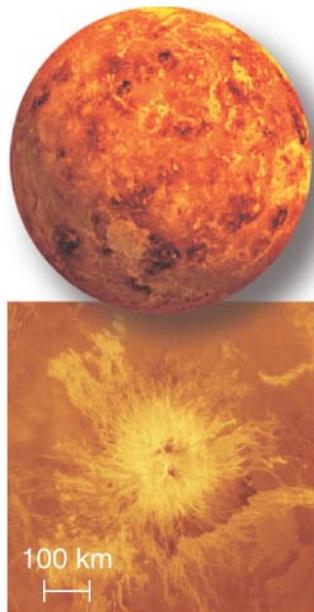
# Planetary surfaces & interiors

**Mercury**



Heavily cratered Mercury has long steep cliffs (arrow).

**Venus**



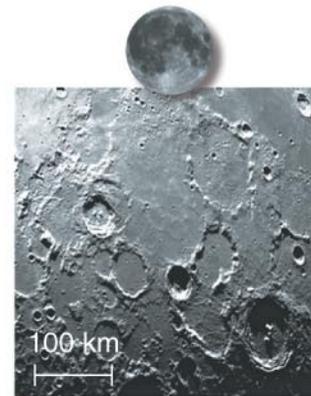
Cloud-penetrating radar revealed this twin-peaked volcano on Venus.

**Earth**



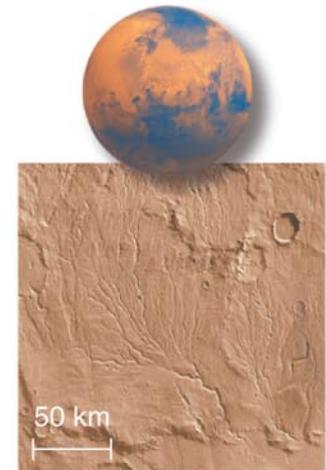
A portion of Earth's surface as it appears without clouds.

**Earth's Moon**



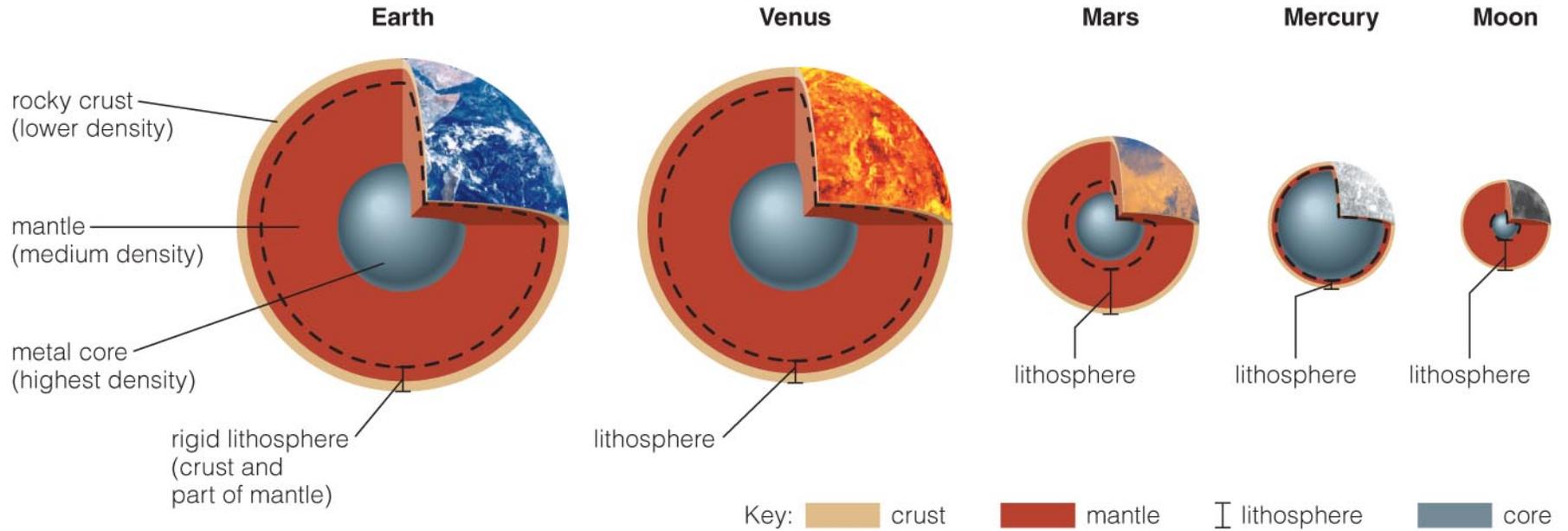
The Moon's surface is heavily cratered in most places.

**Mars**

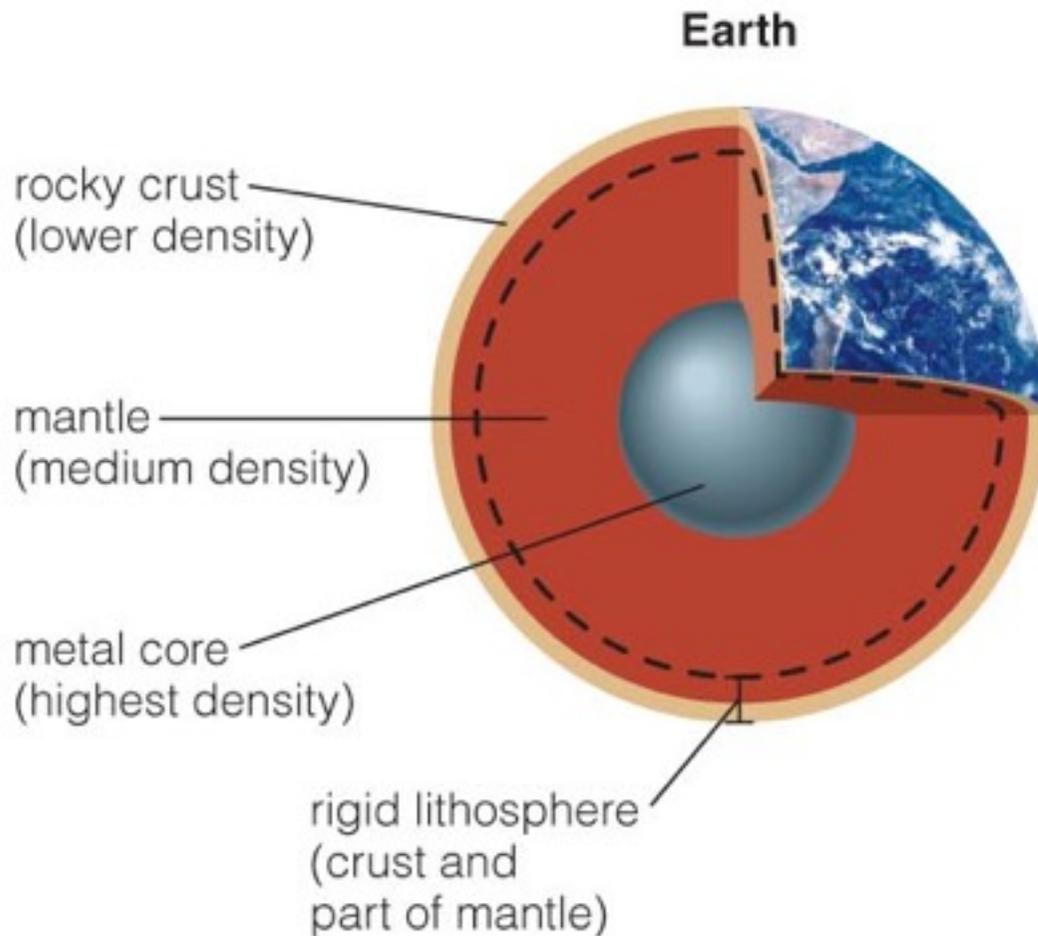


Mars has features that look like dry riverbeds; note the impact craters.

# Planetary surfaces & interiors

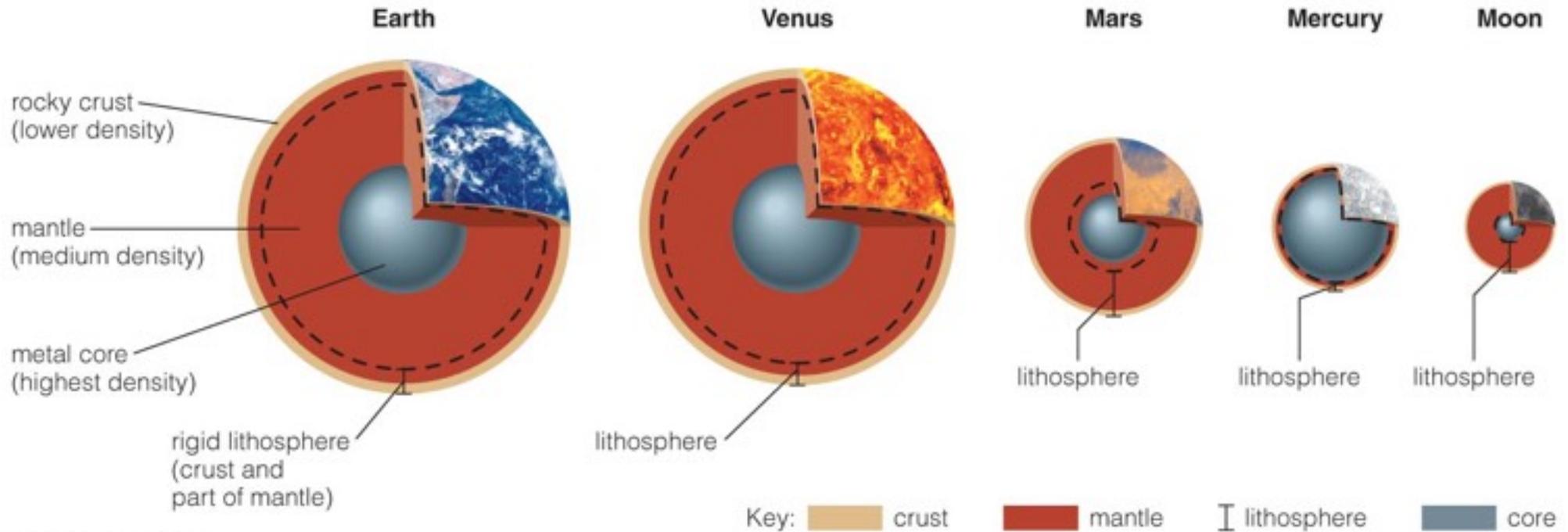


# Earth's Interior



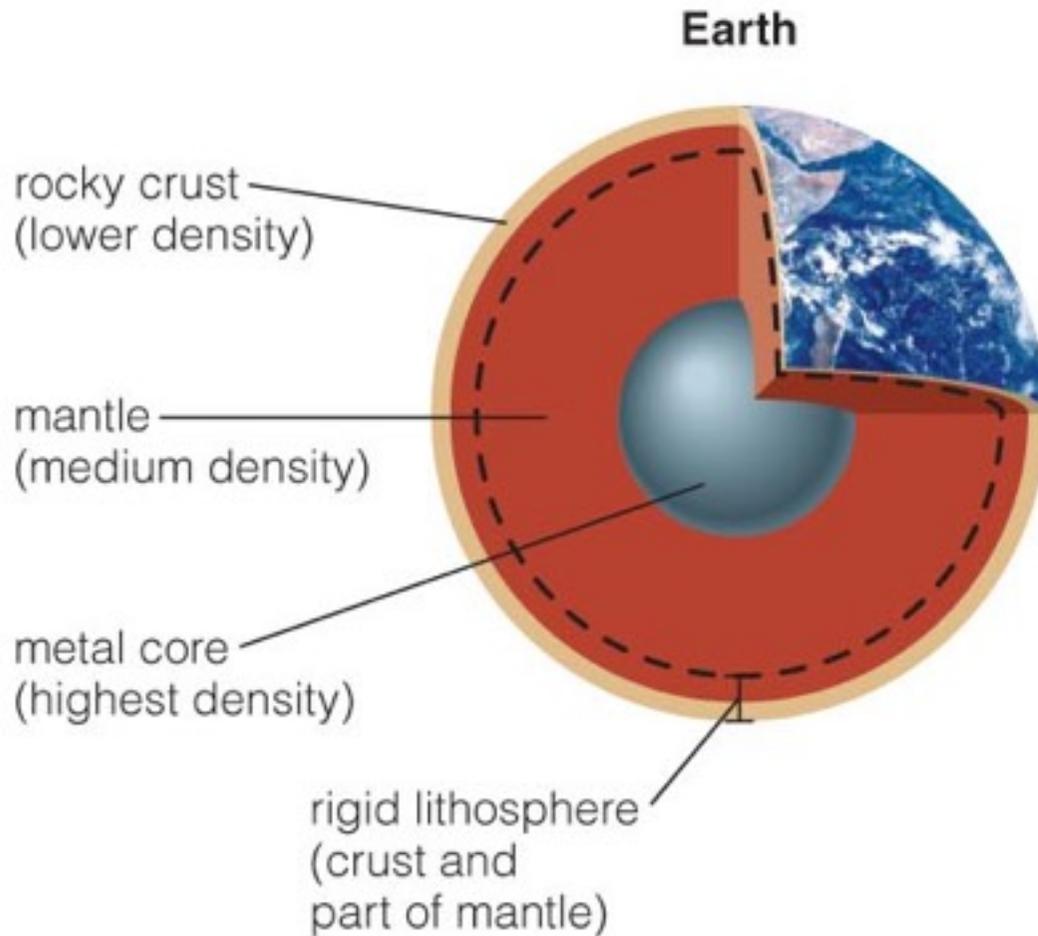
- **Core:** highest density; nickel and iron
- **Mantle:** moderate density; silicon, oxygen, etc.
- **Crust:** lowest density; granite, basalt, etc.

# Terrestrial Planet Interiors



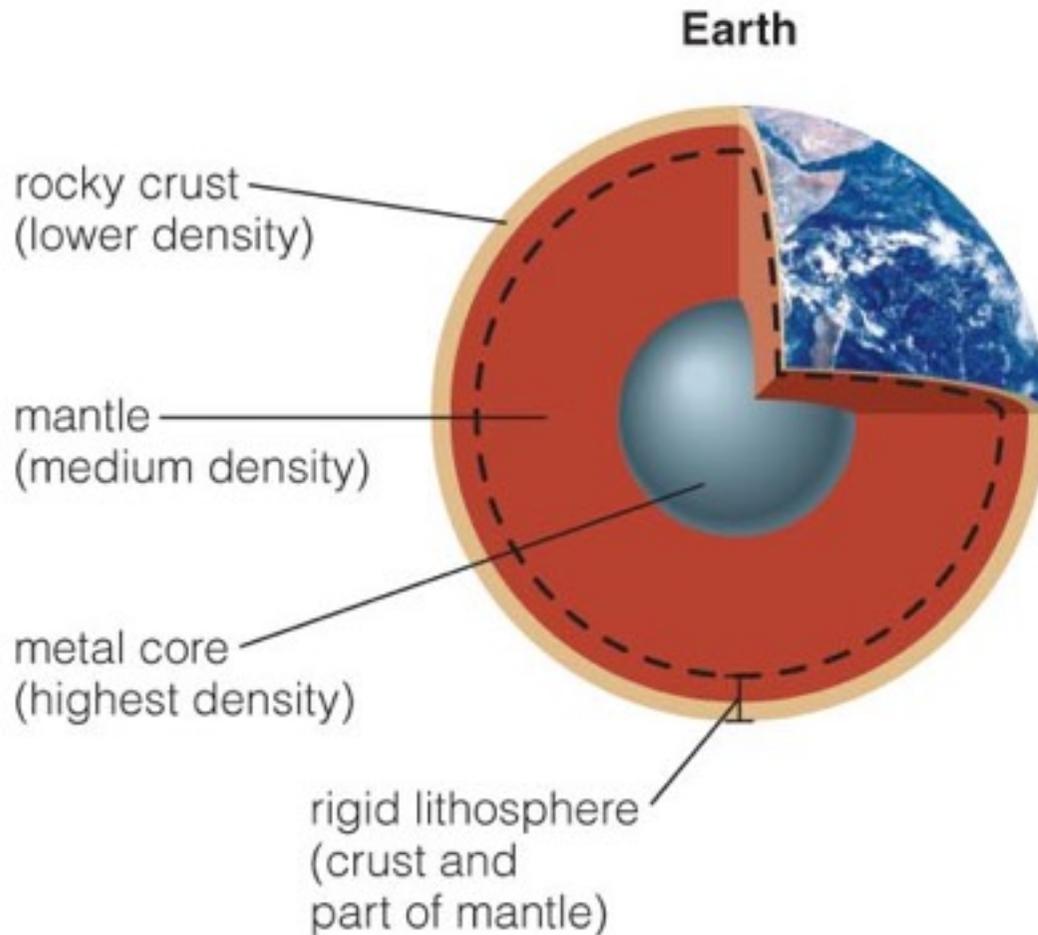
- Applying what we have learned about Earth's interior to other planets tells us what their interiors are probably like.

# Differentiation



- Gravity pulls high-density material to center.
- Lower-density material rises to surface.
- Material ends up separated by density.

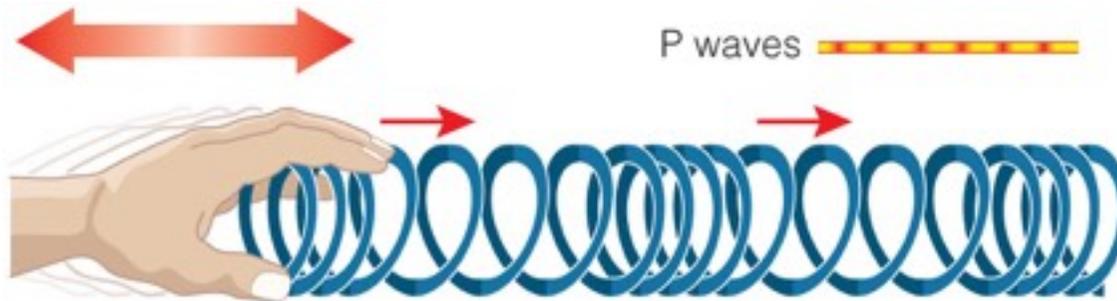
# Lithosphere



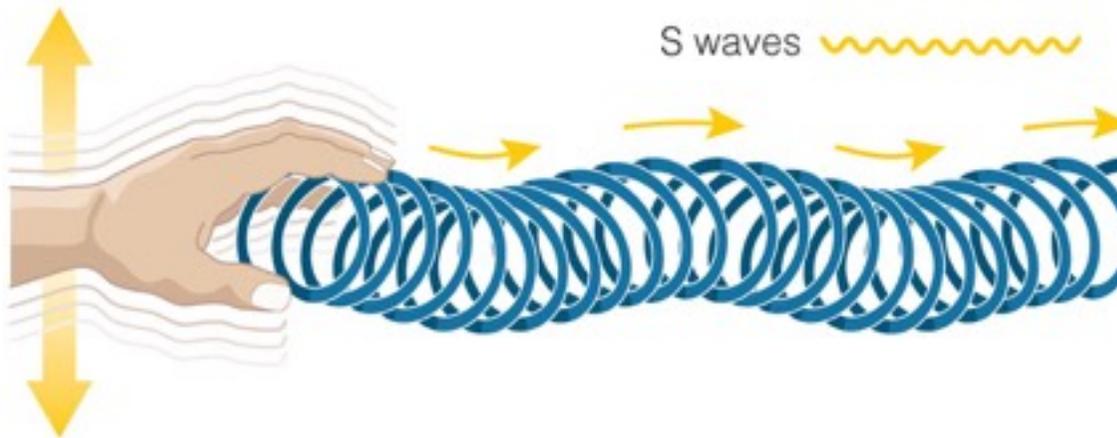
- A planet's outer layer of cool, rigid rock is called the *lithosphere*.
- It "floats" on the warmer, softer rock that lies beneath.

# Special Topic:

How do we know what's inside Earth?



- P waves push matter back and forth.

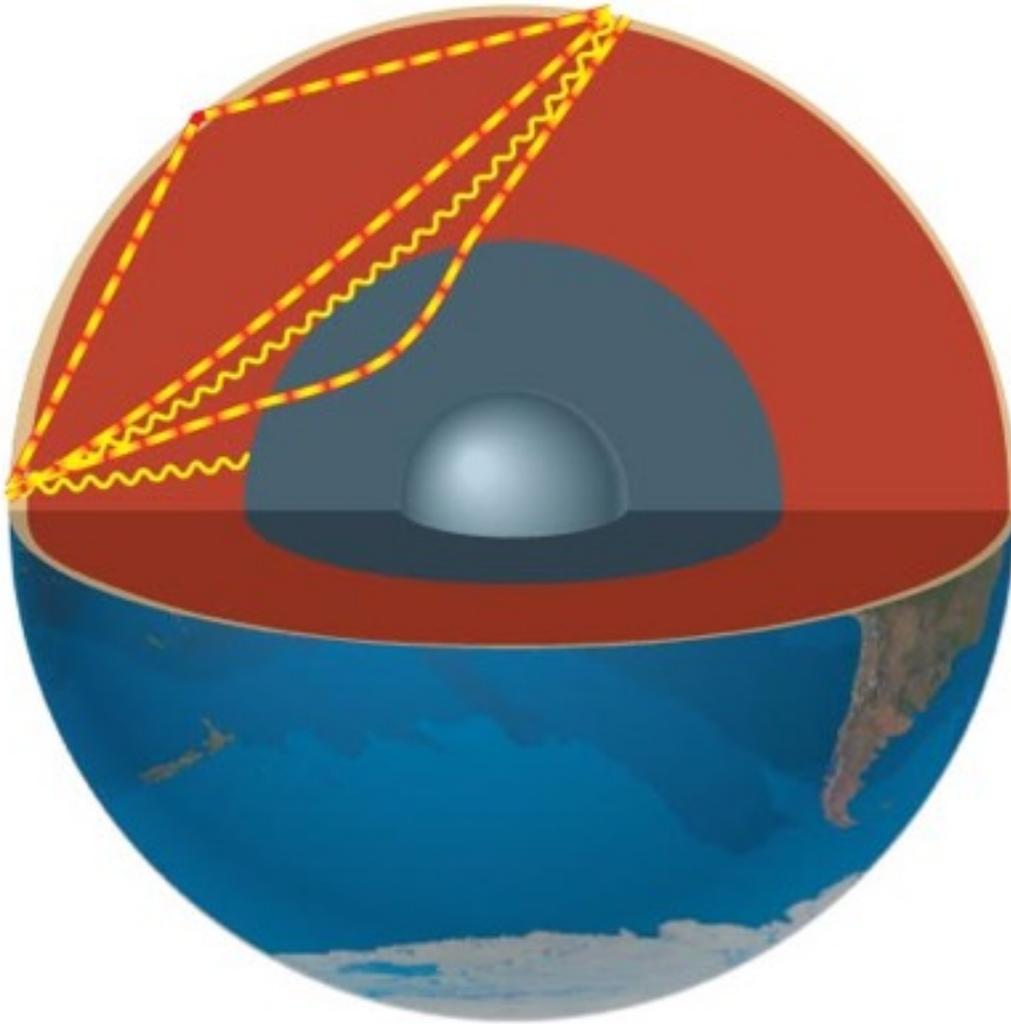


- S waves shake matter side to side



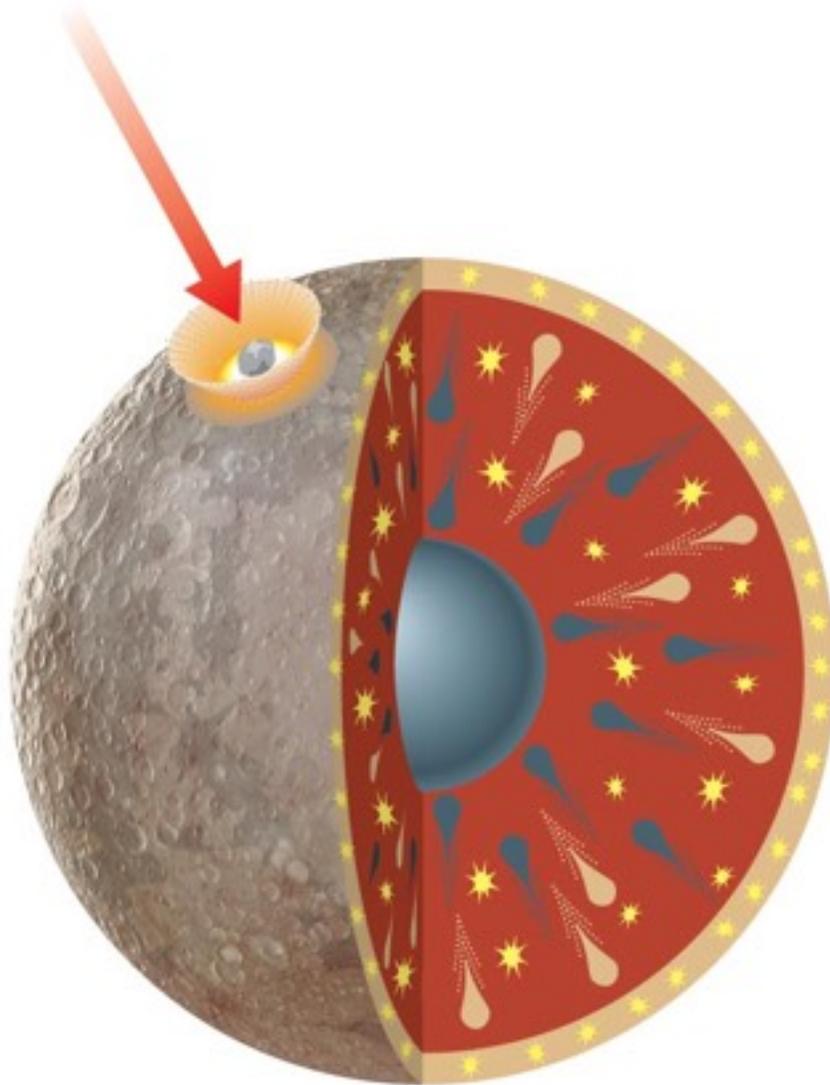
# Special Topic:

How do we know what's inside Earth?



- P waves go through Earth's core, but S waves do not.
- We conclude that Earth's core must have a liquid outer layer.

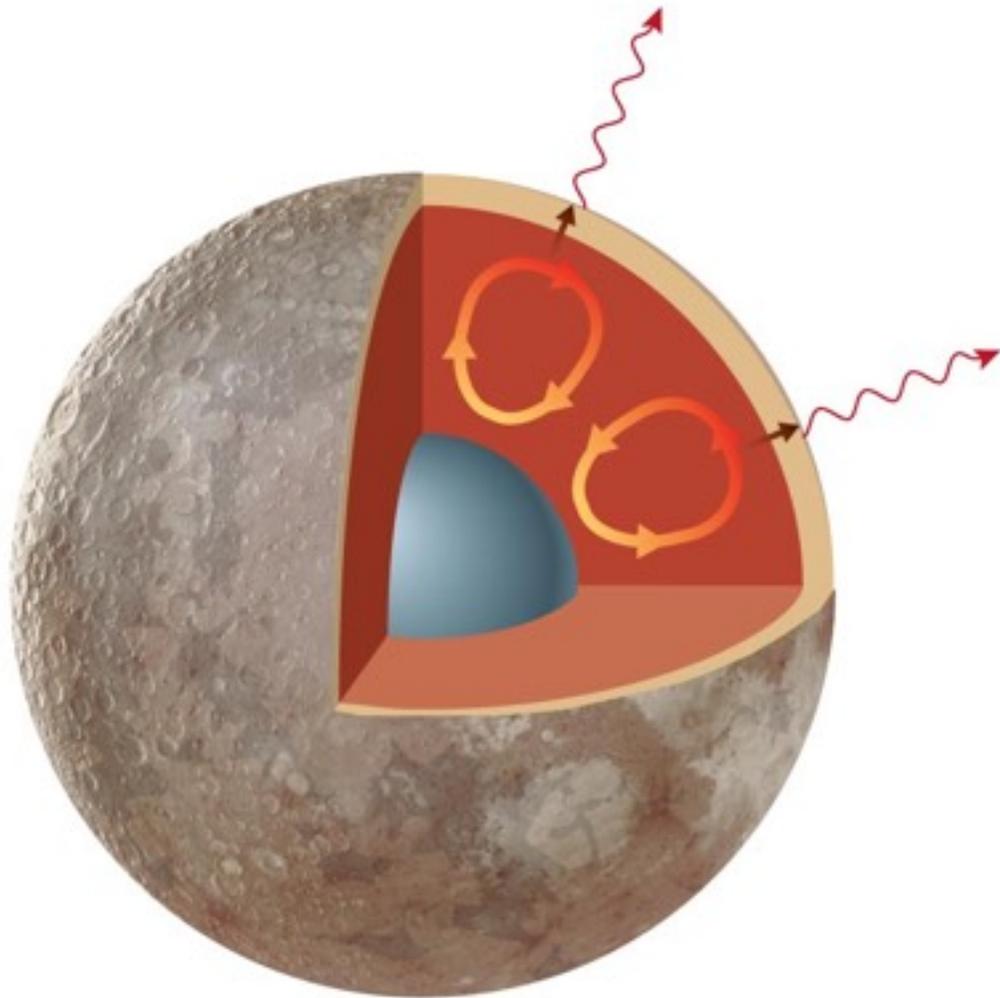
# Heating of Planetary Interiors



- Accretion and differentiation when planets were young
- Radioactive decay is most important heat source today.

*Heat drives geological activity*

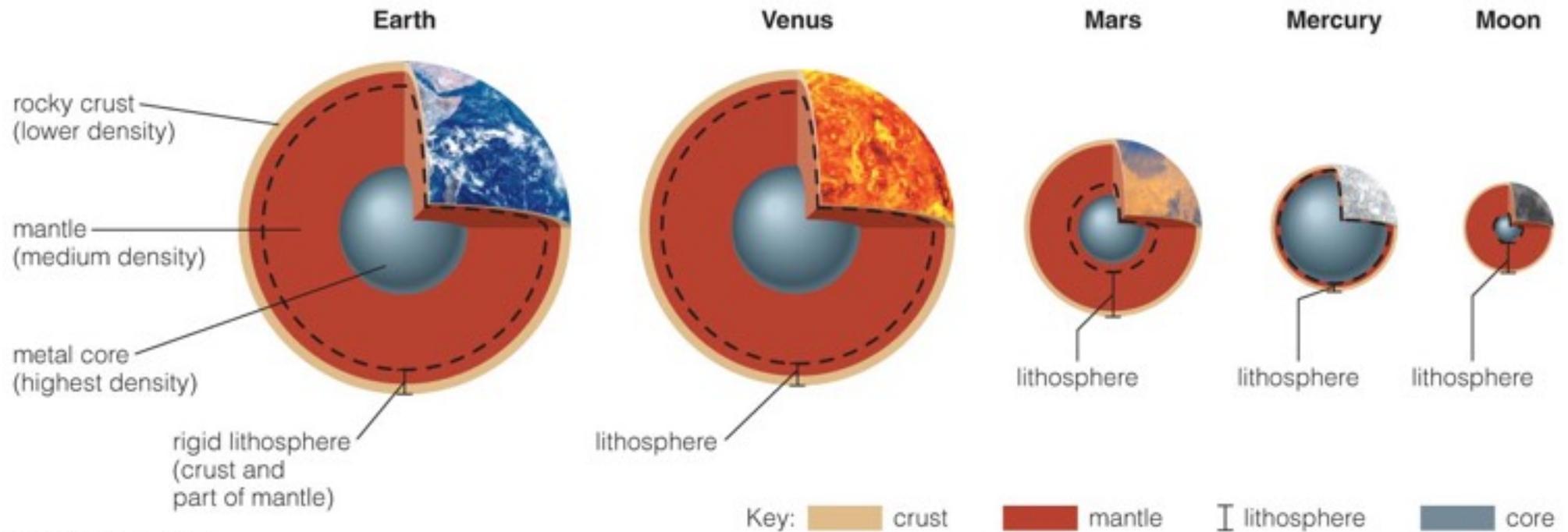
# Cooling of Planetary Interiors



- **Convection** transports heat as hot material rises and cool material falls.
- **Conduction** transfers heat from hot material to cool material.
- **Radiation** sends energy into space.

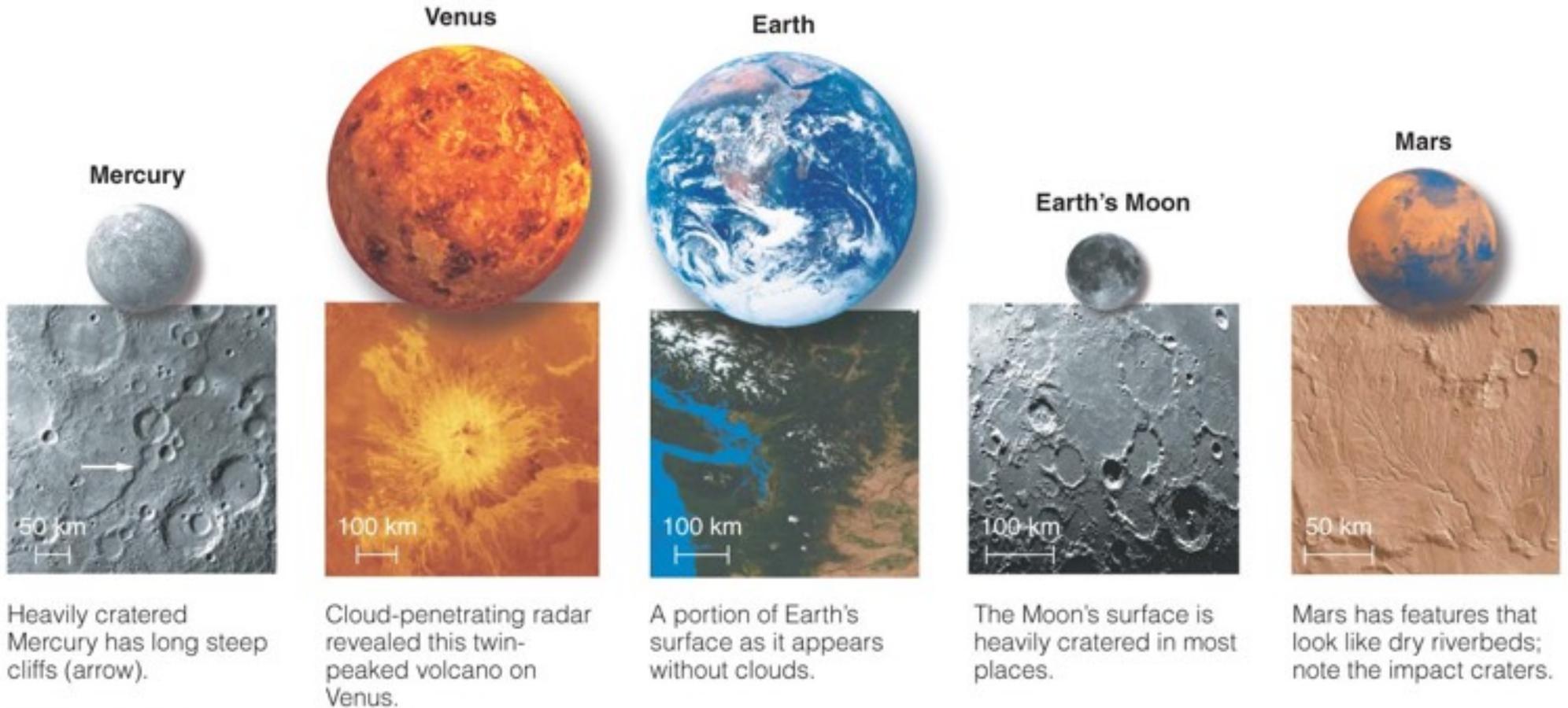
*Heat drives geological activity*

# Role of Size



- Smaller worlds cool off faster and harden earlier.
  - cooling time depends on surface area/volume ratio
- The Moon and Mercury are now geologically "dead."

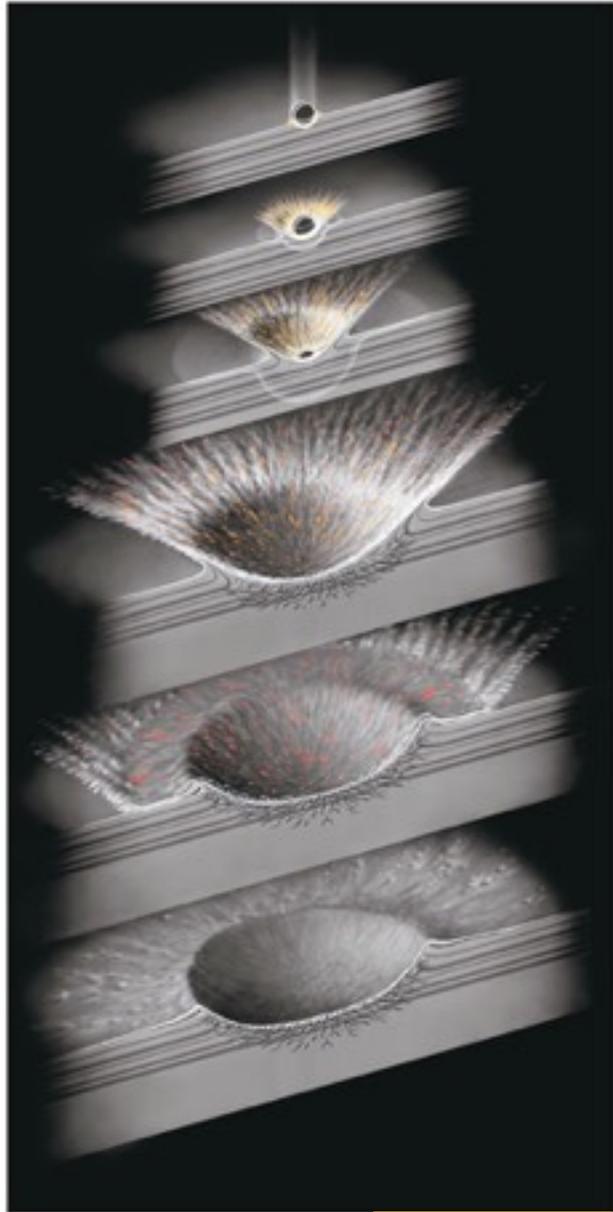
# What processes shape planetary surfaces?



# Processes That Shape Surfaces

- Impact cratering
  - Impacts by asteroids or comets
- Volcanism
  - Eruption of molten rock onto surface
- Tectonics
  - Disruption of a planet's surface by internal stresses
- Erosion
  - Surface changes made by wind, water, or ice

# Impact Cratering



Interactive Figure 

- Most cratering happened soon after the solar system formed.
- Craters are about 10 times wider than object that made them.
- Small craters greatly outnumber large ones.

# Impact Craters



**a** Meteor Crater in Arizona is more than a kilometer across and almost 200 meters deep. It was created around 50,000 years ago by the impact of a metallic asteroid about 50 meters across.

## Meteor Crater (Arizona)



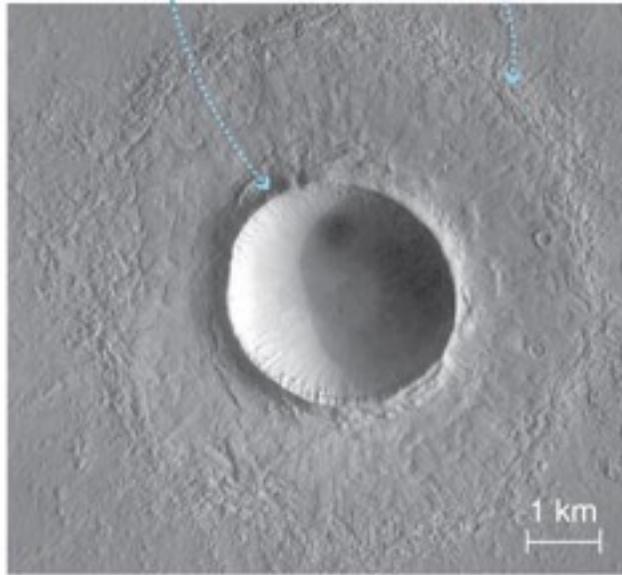
**b** This photo shows a crater, named Tycho, on the Moon. Note the classic shape and central peak.

## Tycho Crater (Moon)

# Impact Craters on Mars

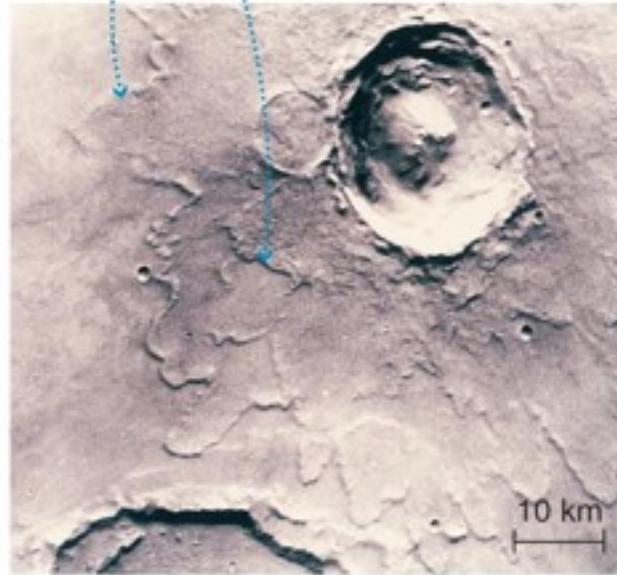
*A simple bowl-shaped crater, showing a sharp rim . . .*

*. . . and a ring of ejected debris.*



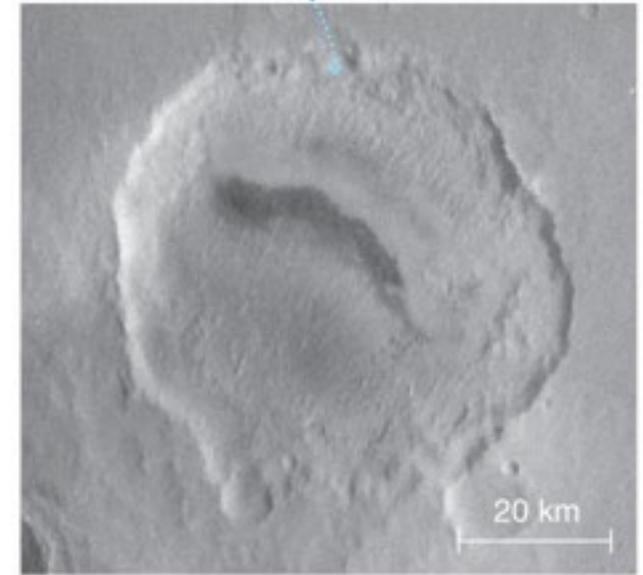
**a** A crater with a typical bowl shape.

*Unusual ridges suggest the impact debris was muddy.*



**b** This crater was probably made by an impact into icy ground.

*This crater rim looks like it was eroded by rainfall.*



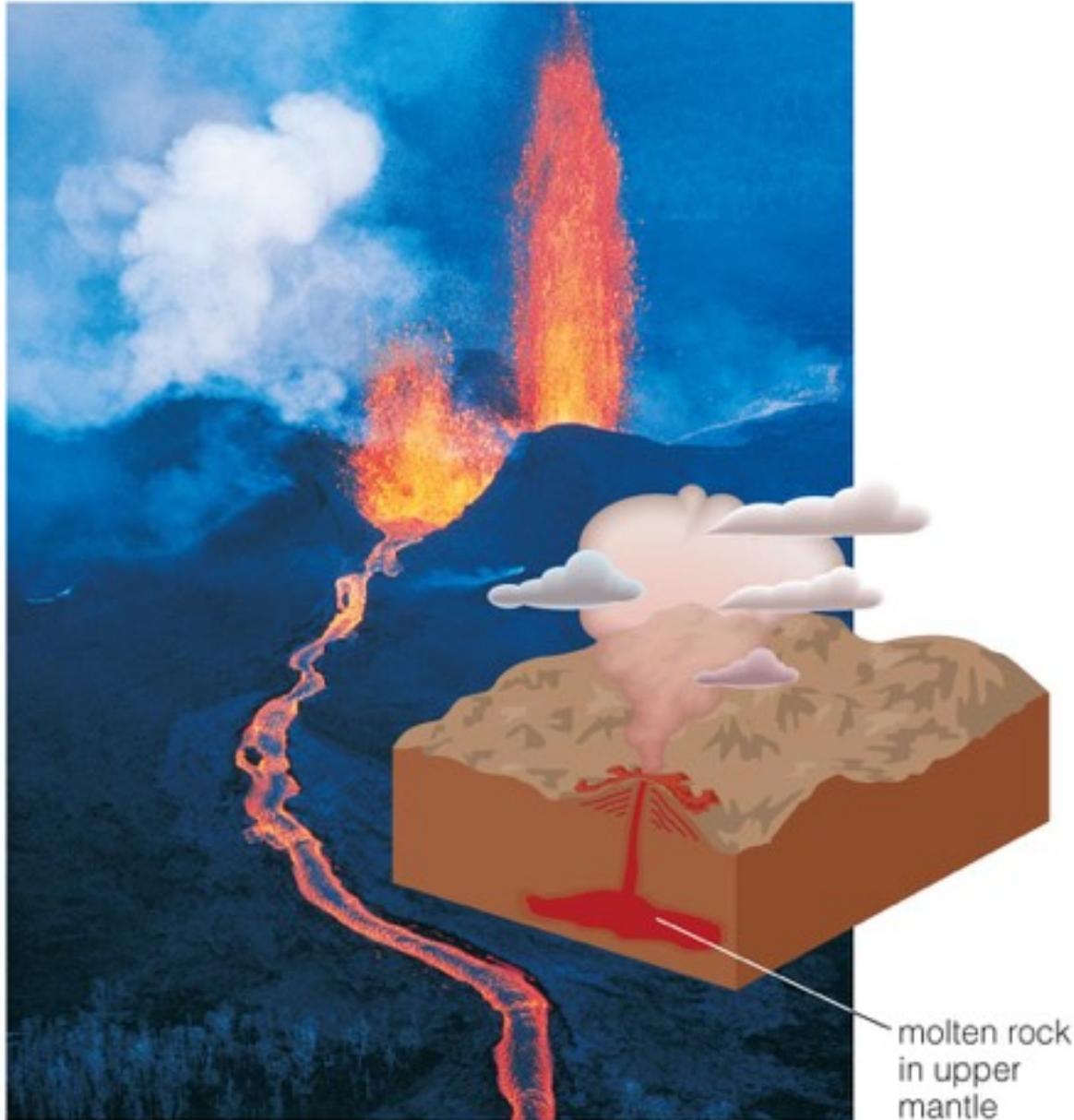
**c** This crater shows evidence of erosion.

"Standard" crater

Impact into icy ground

Eroded crater

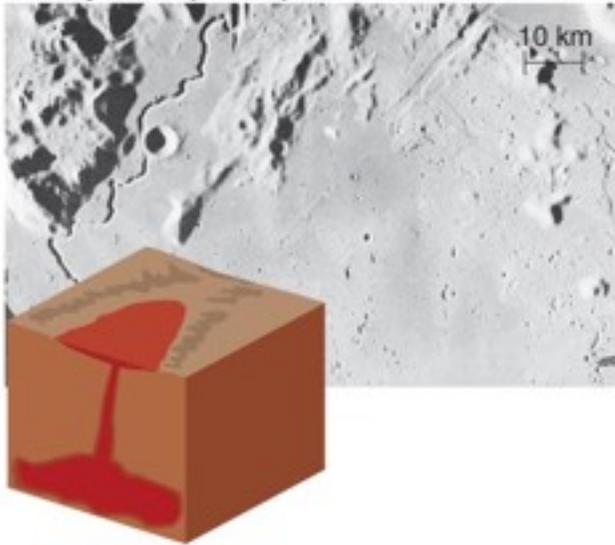
# Volcanism



- Volcanism happens when molten rock (magma) finds a path through lithosphere to the surface.
- Molten rock is called *lava* after it reaches the surface.

# Lava and Volcanoes

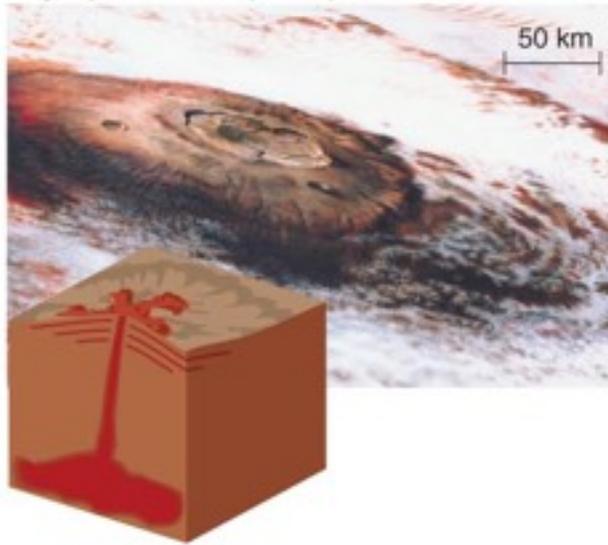
Lava plains (maria) on the Moon



a Very runny lava makes flat lava plains like these on the Moon. The long, winding channel near the upper left was made by a river of molten lava.

Runny lava makes flat lava plains.

Olympus Mons (Mars)



b Slightly thicker lava makes shallow-sloped shield volcanoes, such as Olympus Mons on Mars.

Slightly thicker lava makes broad *shield volcanoes*.

Mount Hood (Earth)



c The thickest lavas make steep-sloped stratovolcanoes like Oregon's Mount Hood.

Thickest lava makes steep *stratovolcanoes*.

# Outgassing



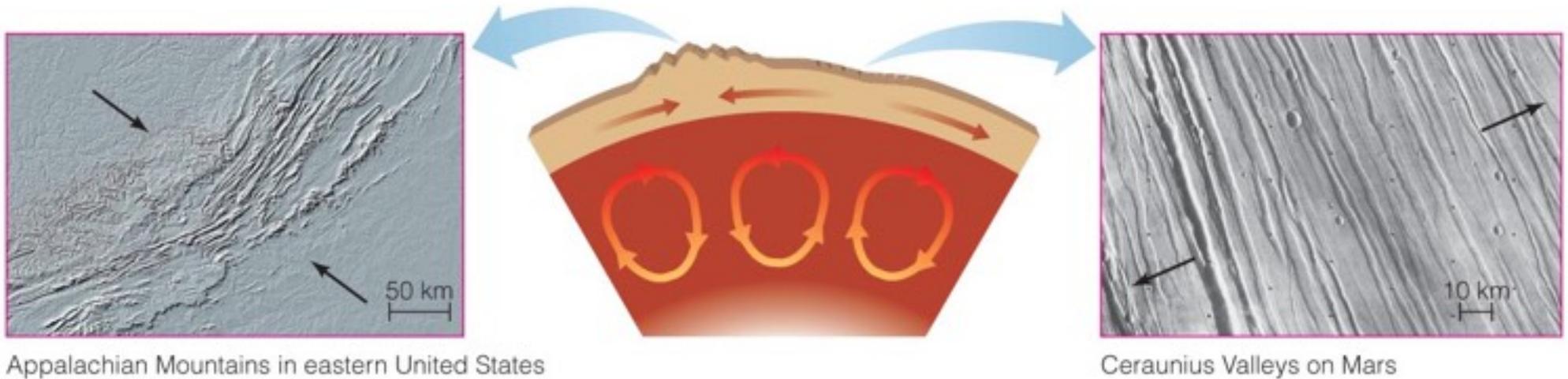
a The eruption of Mount St. Helens, May 18, 1980.



b More gradual outgassing from a volcanic vent in Volcanoes National Park, Hawaii.

- Volcanism also releases gases from Earth's interior into the atmosphere.
- How planets get an atmosphere in the first place!

# Tectonics

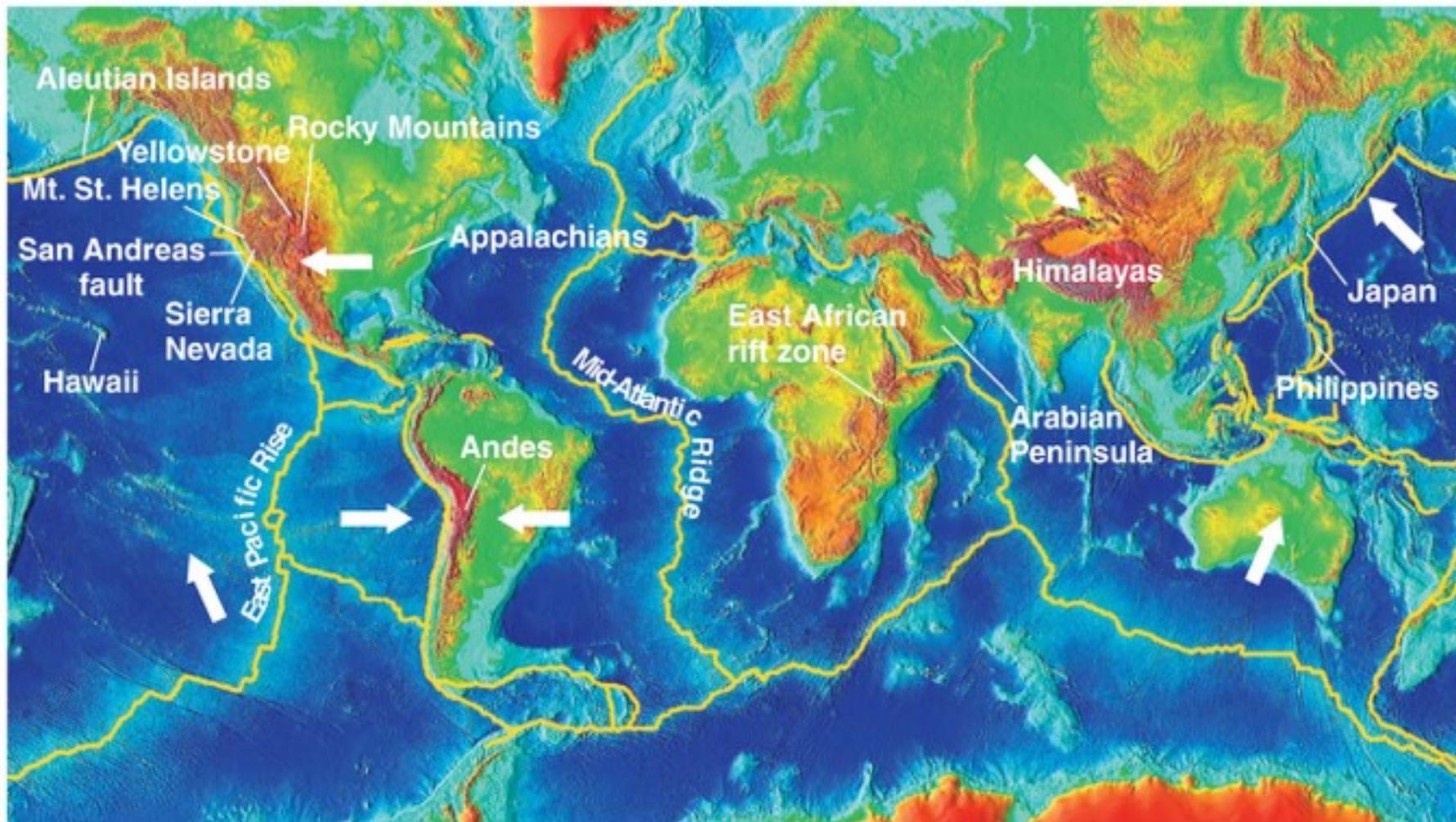


Interactive Figure

- Convection of the mantle creates stresses in the crust called tectonic forces.
- Compression of crust creates mountain ranges.
- Valley can form where crust is pulled apart.

# Plate Tectonics on Earth

- Earth's continents slide around on separate plates of crust.



# Erosion

- Erosion is a blanket term for weather-driven processes that break down or transport rock.
- Processes that cause erosion include:
  - glaciers
  - rivers
  - wind

# Erosion by Water



- The Colorado River continues to carve Grand Canyon.

# Local examples of Erosion



# Erosion by Ice



- Glaciers carved the Yosemite Valley.

# Erosion by Wind



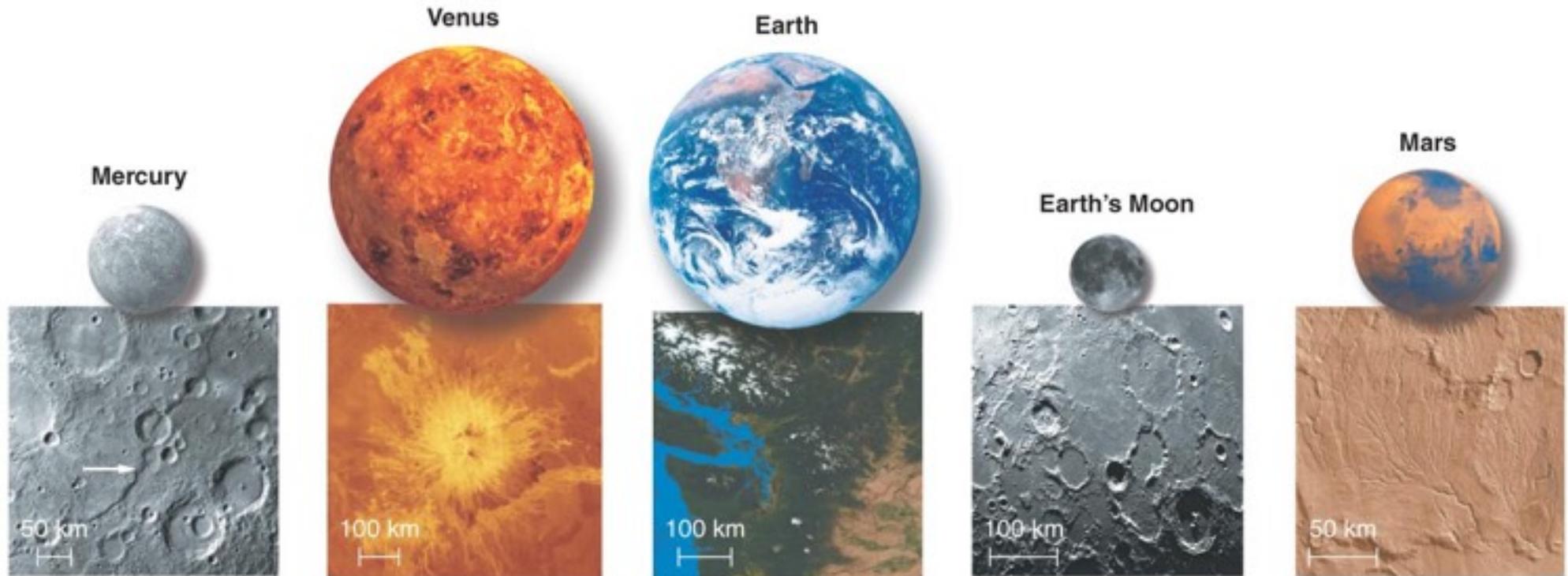
- Wind wears away rock and builds up sand dunes.
- Also active on Mars

# Erosional Debris

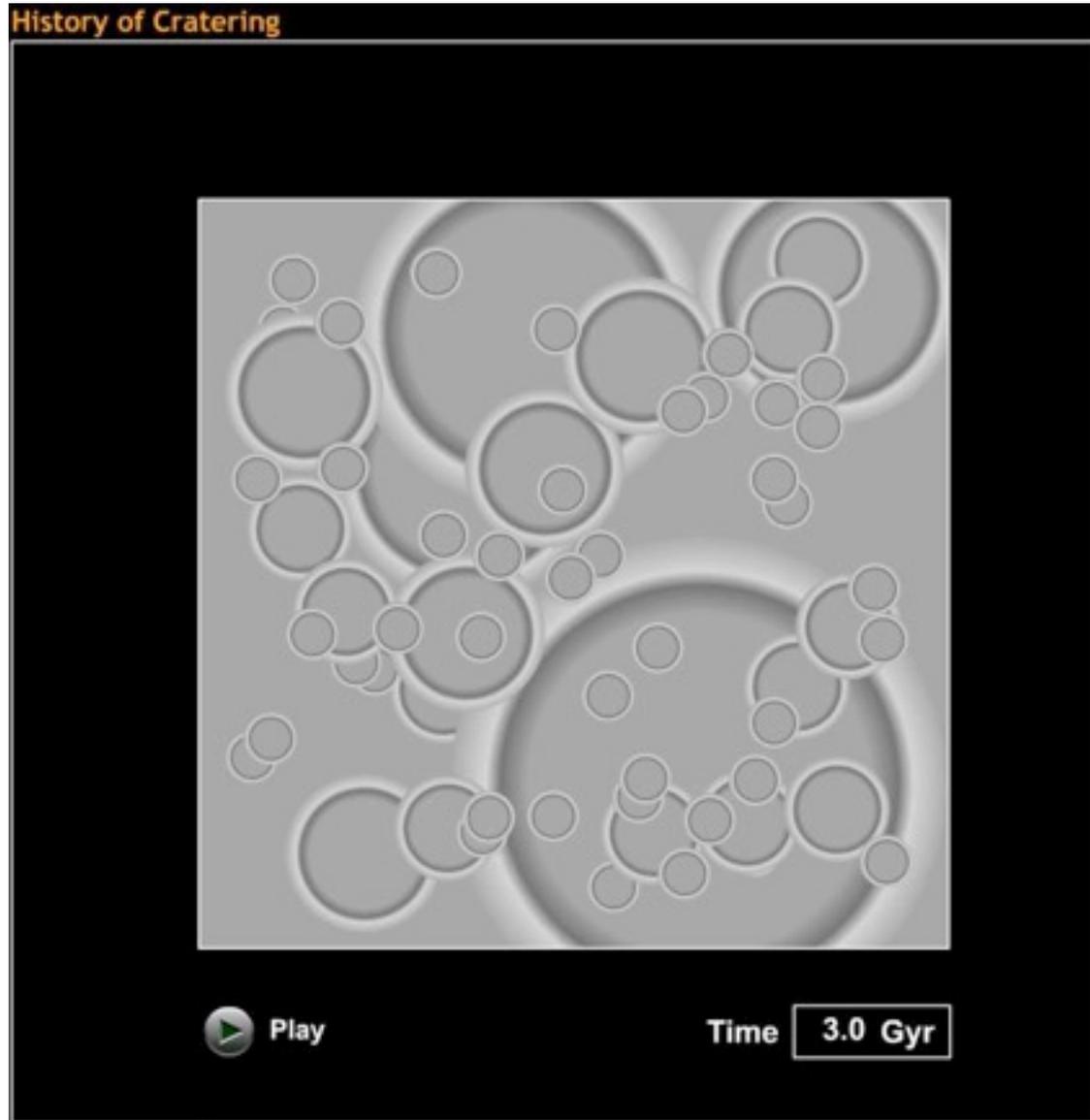


- Erosion can create new features such as deltas by depositing debris.

# How do impact craters reveal a surface's geological age?



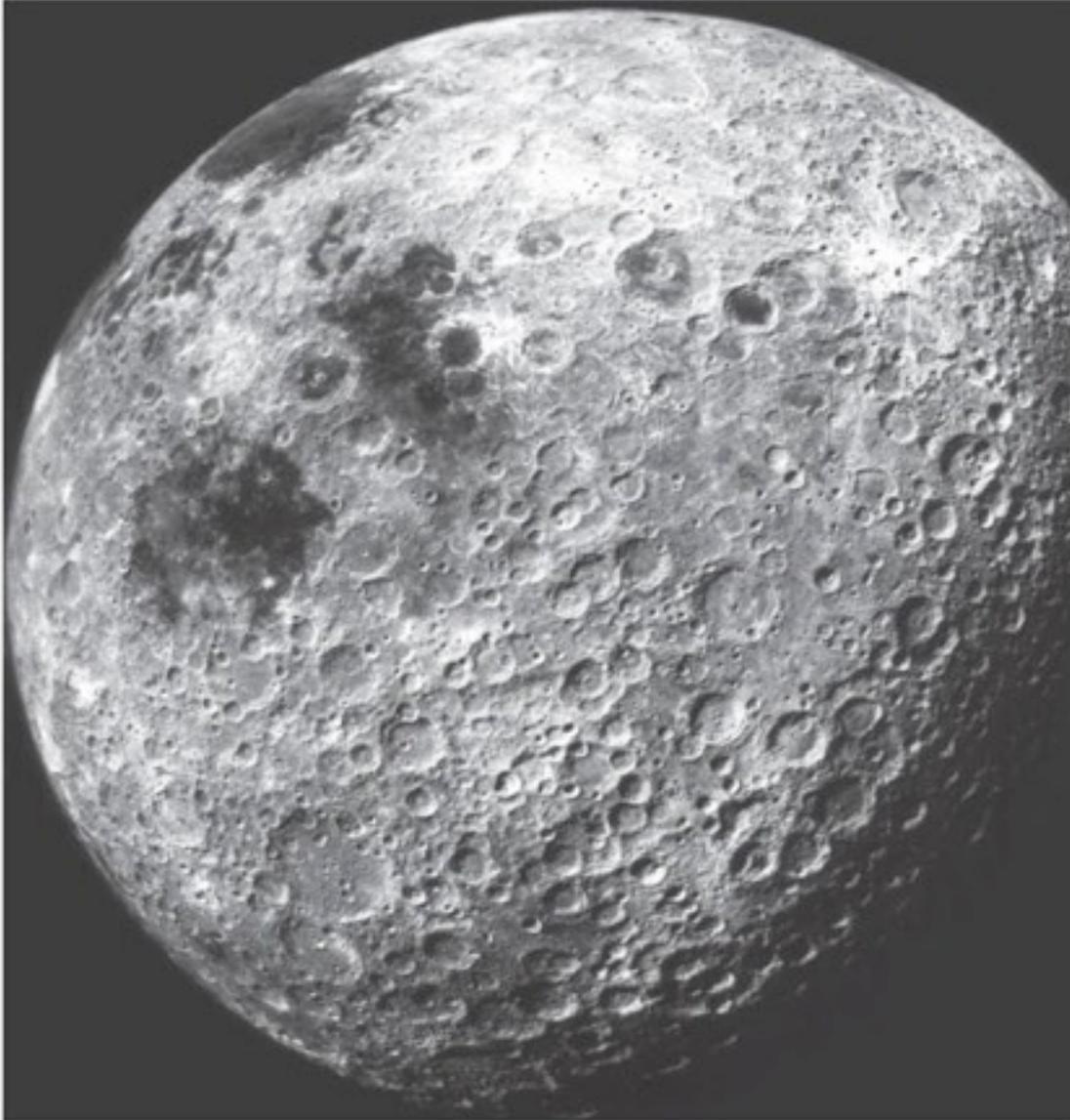
# History of Cratering



Interactive Figure

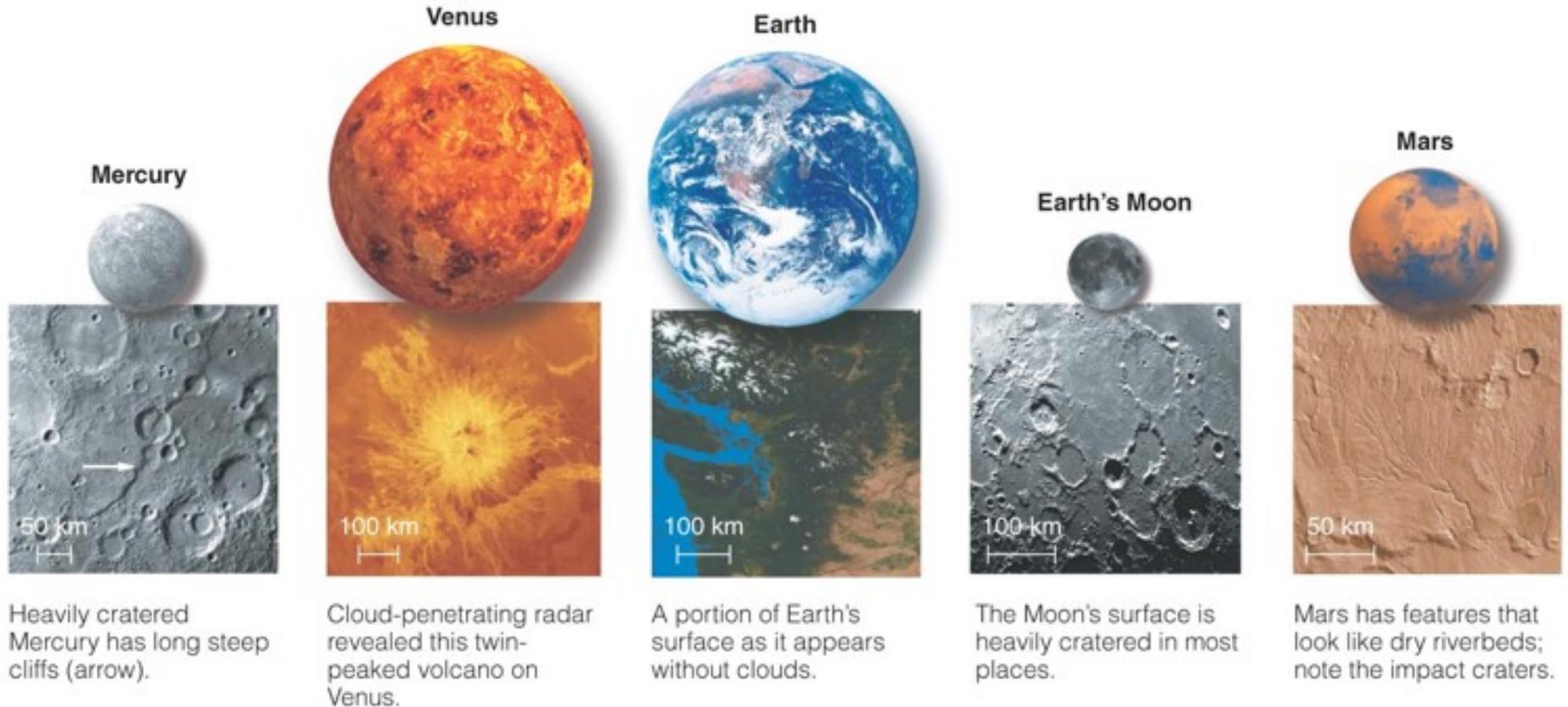
- Most cratering happened in the first billion years.
- A surface with many craters has not changed much in 3 billion years.

# Cratering of Moon



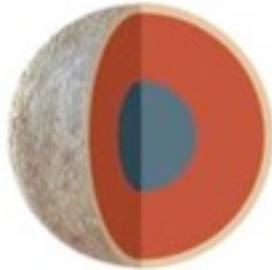
- Some areas of Moon are more heavily cratered than others.
- Younger regions were flooded by lava after most cratering.
  - *mare*

# Why do the terrestrial planets have different geological histories?

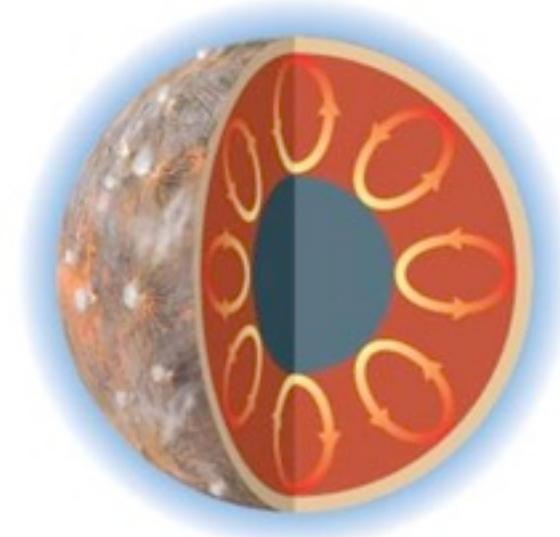


# Role of Planetary Size

Small Terrestrial Planets

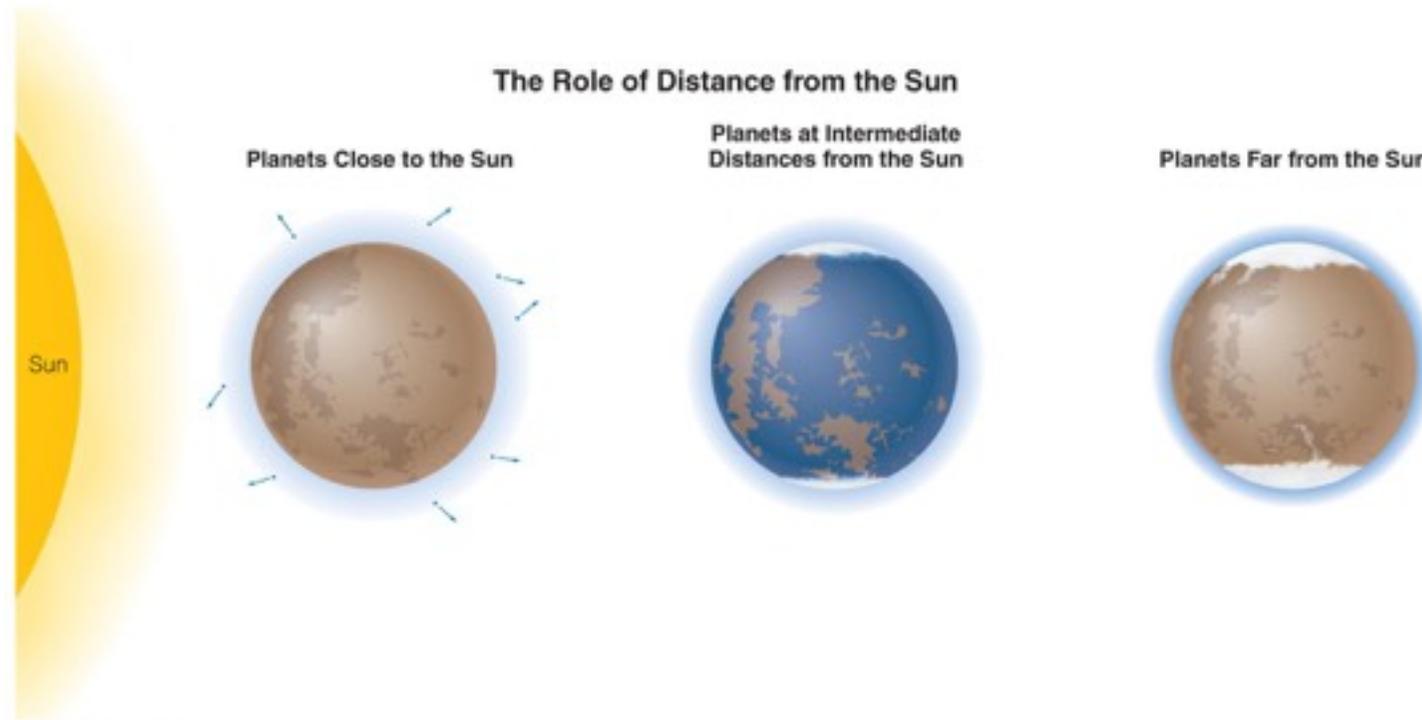


Large Terrestrial Planets



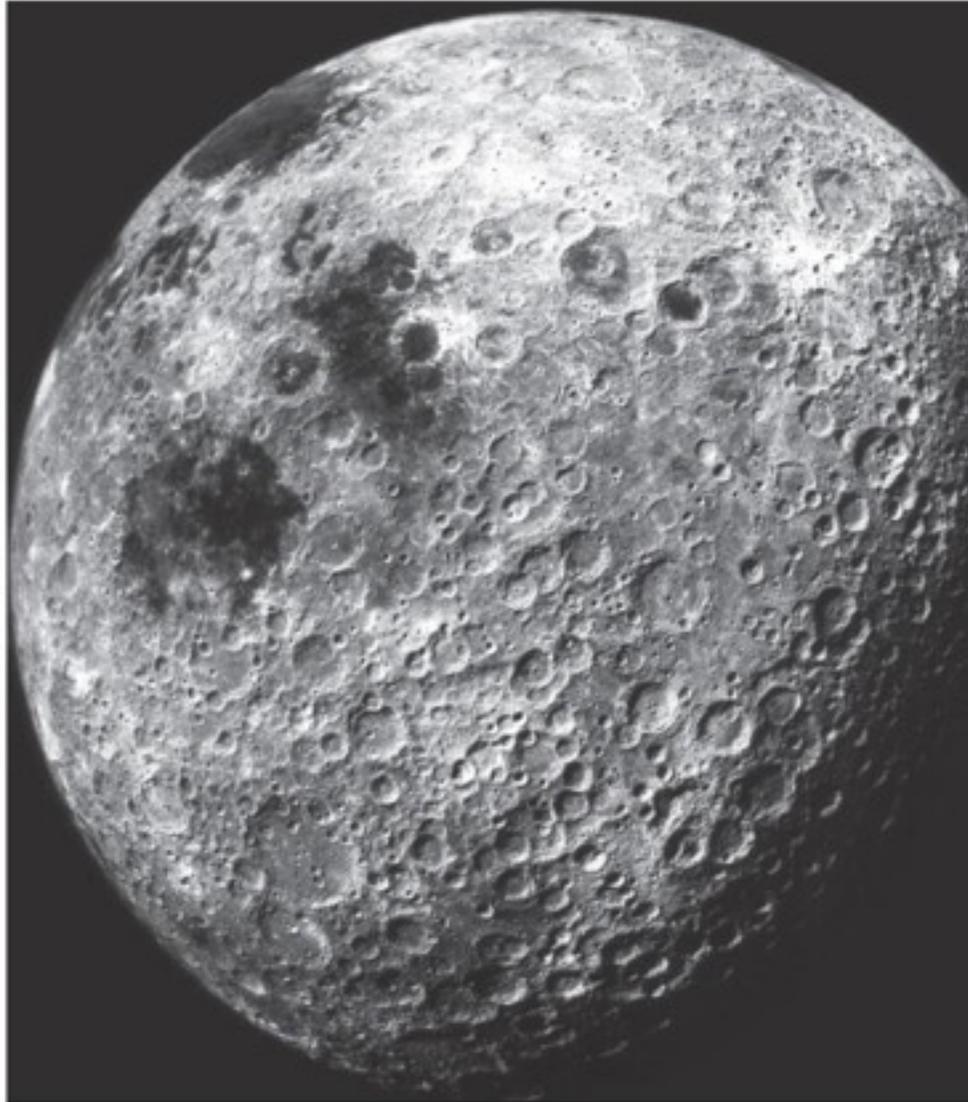
- Smaller worlds cool off faster and harden earlier.
- Larger worlds remain warm inside, promoting volcanism and tectonics.
- Larger worlds also have more erosion because their gravity retains an atmosphere.

# Role of Distance from Sun

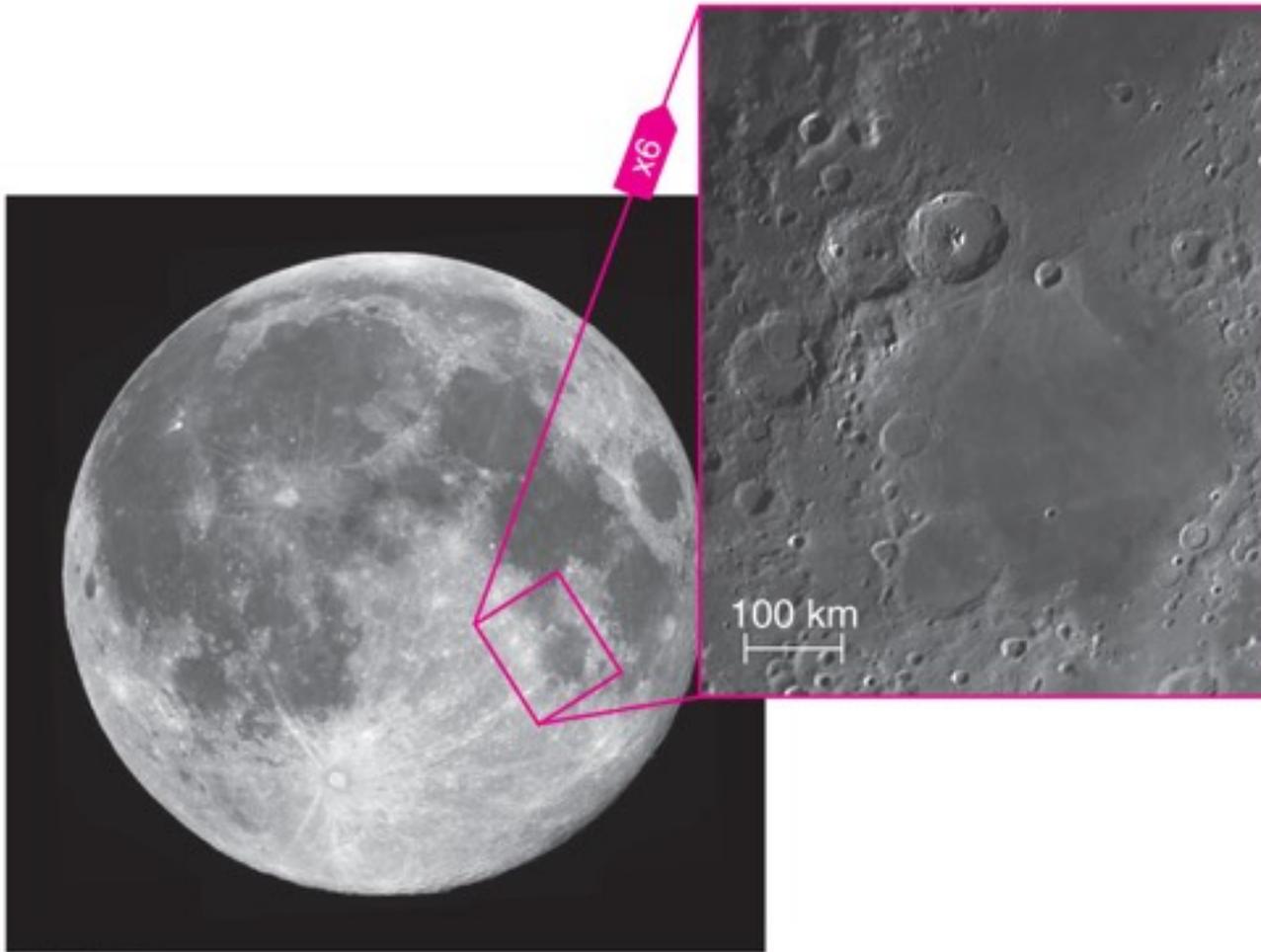


- Planets close to the Sun are too hot for rain, snow, ice and so have less erosion.
- Hot planets have more difficulty retaining an atmosphere.
- Planets far from the Sun are too cold for rain, limiting erosion.
- Planets with liquid water have the most erosion.

# What geological processes shaped our Moon?



# Lunar Maria



- Smooth, dark lunar maria are less heavily cratered than lunar highlands.
- Maria were made by floods of runny lava.

# Formation of Lunar Maria



Early surface is covered with craters.

Large impact crater weakens crust.

Heat build-up allows lava to well up to surface.

Cooled lava is smoother and darker than surroundings.

# Tectonic Features



- Wrinkles arise from cooling and the contraction of a lava flood.

# Geologically Dead

- Moon is considered geologically "dead" because geological processes have virtually stopped.
- Cooling process essentially complete
  - no more geology because there isn't any interior heat to drive it

