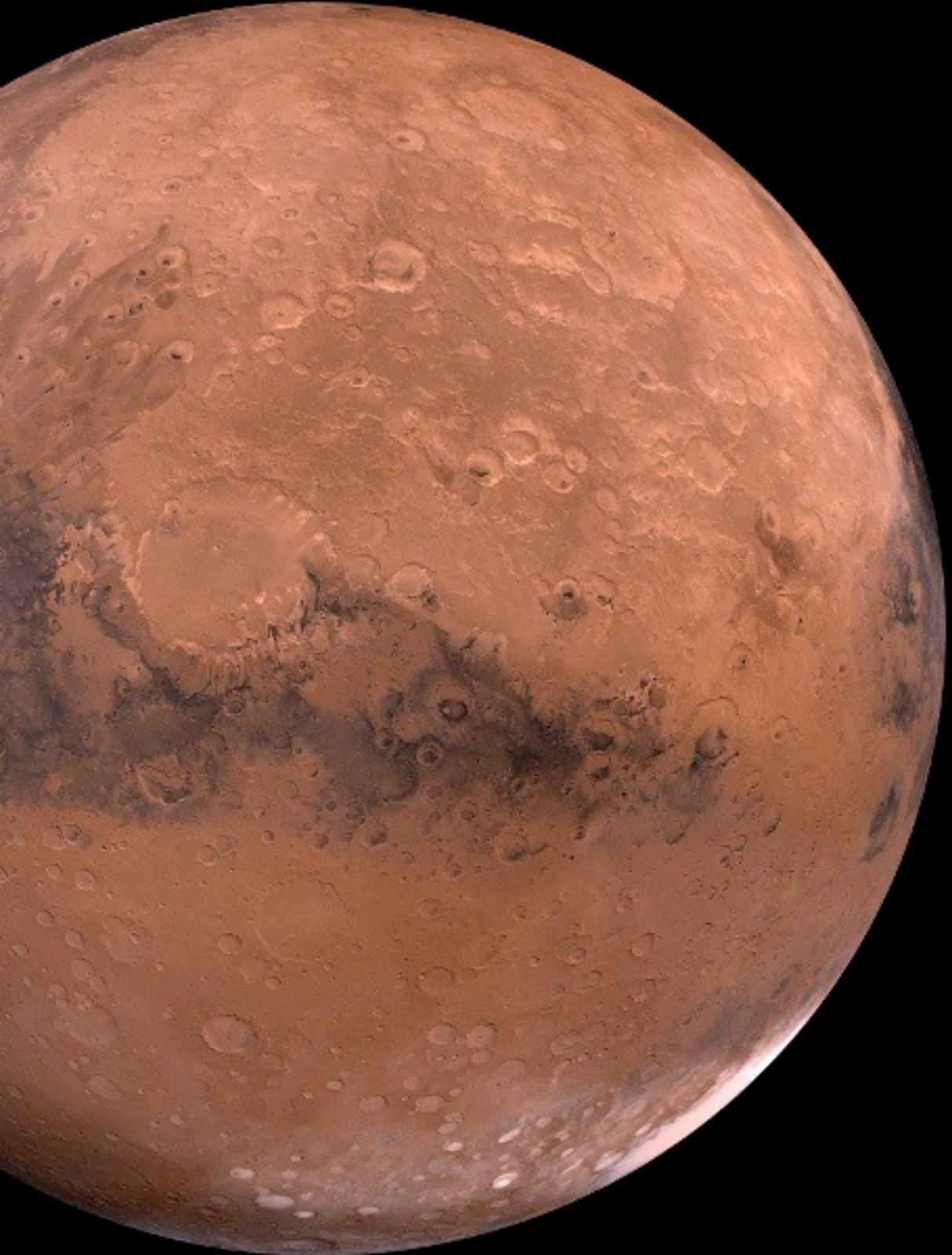


Today

- Terrestrial Planet Geology

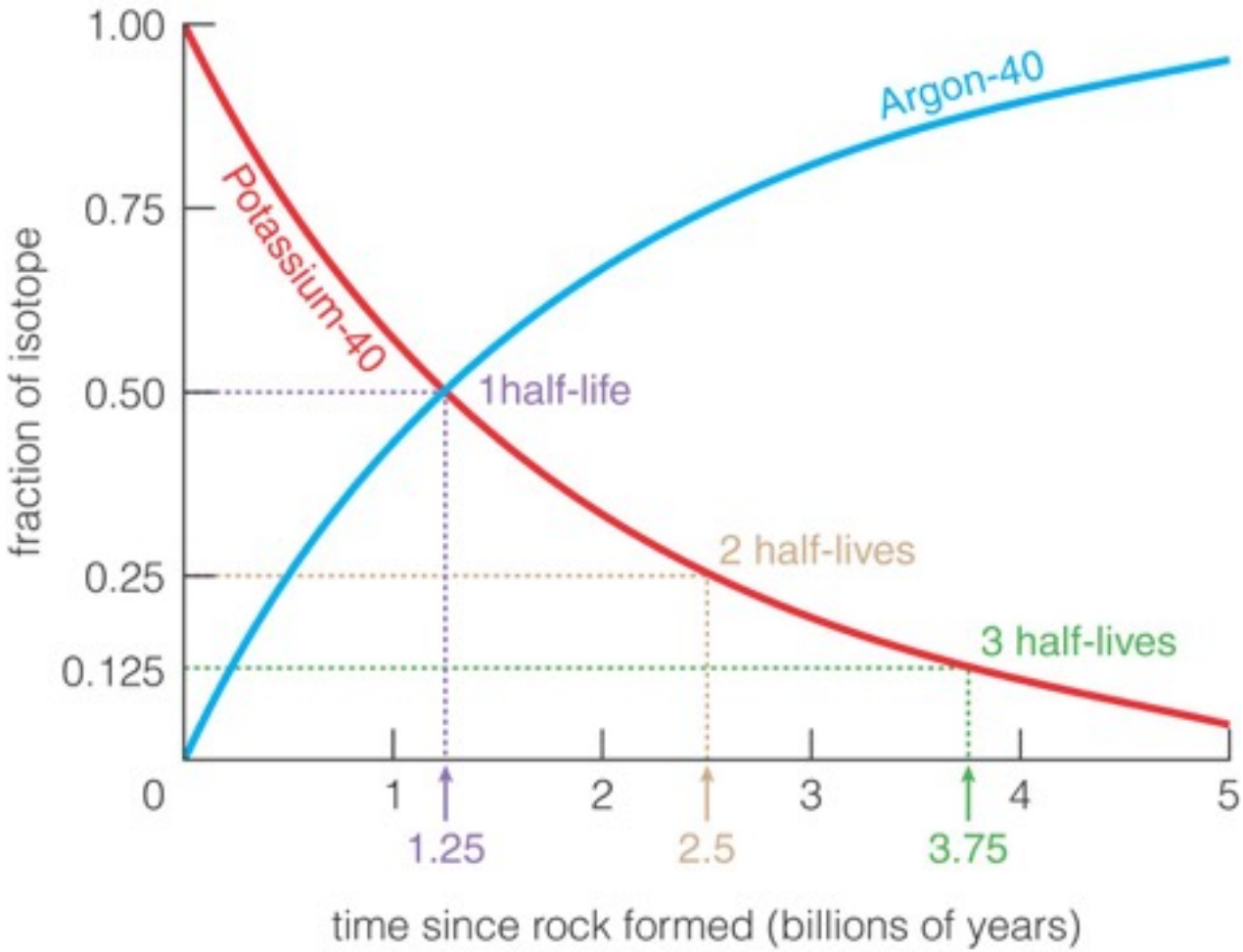
Events

- Fall break next week
  - no class Tuesday

When did the planets form?

- We cannot find the age of a planet, but we can find the ages of the rocks that make it up.
- We can determine the age of a rock through careful analysis of the proportions of various atoms and isotopes within it.

Radioactive Decay



- Some isotopes decay into other nuclei.
- A **half-life** is the time for half the nuclei in a substance to decay.

Dating the Solar System

Age dating of meteorites via radio-isotopes tells us that the solar system is about 4.5 billion years old.

A similar age is found for the oldest moon rocks returned by Apollo.

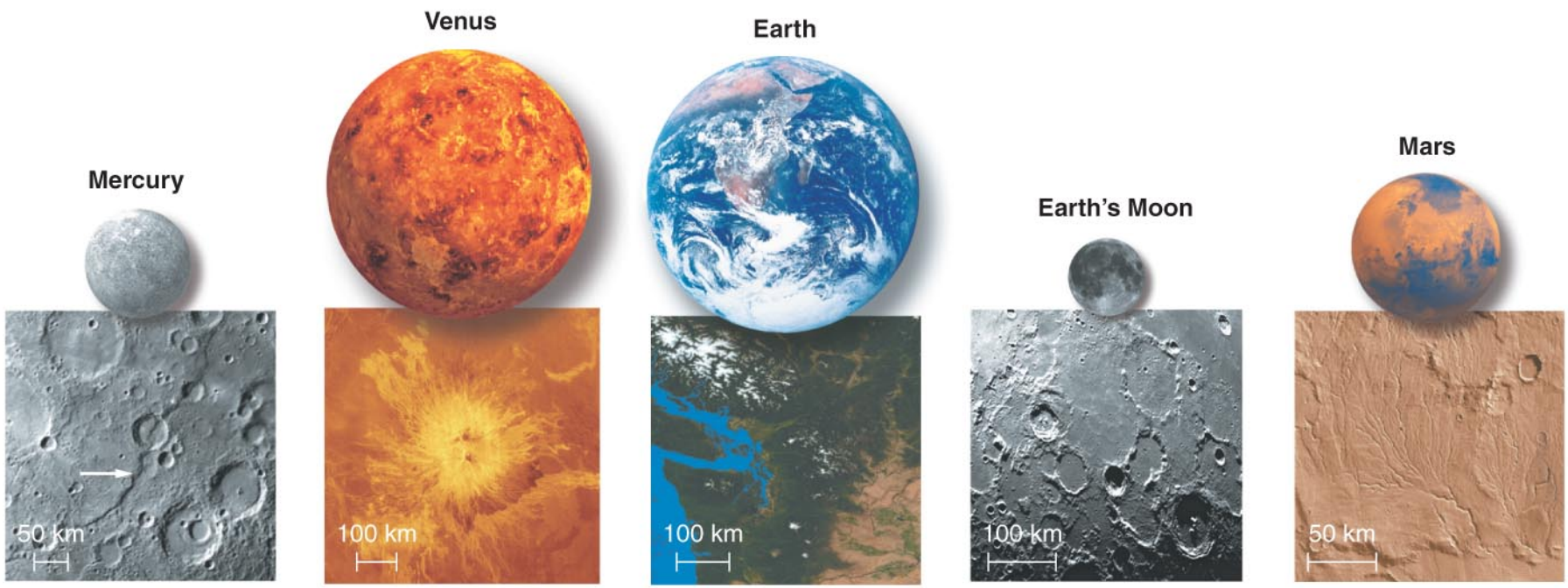
Dating the Solar System

- Radiometric dating tells us that the oldest moon rocks are 4.4 billion years old.
- The oldest meteorites are 4.5 billion years old.
- This dates the age of the solar system to about 4.5 billion years.

Solar System Formation

- The solar system formed about 4.5 billion years ago from the collapse of an interstellar gas cloud (the ***solar nebula***).
- The planets formed by coagulation of smaller particles (planetesimals).
- Planets all line in the same orbital plane, all orbit in the same direction, and mostly spin in the same direction because the angular momentum of the solar nebula was conserved.
- The exceptions may record the lasting effects of the last enormous collisions.

Planetary surfaces & interiors



Heavily cratered Mercury has long steep cliffs (arrow).

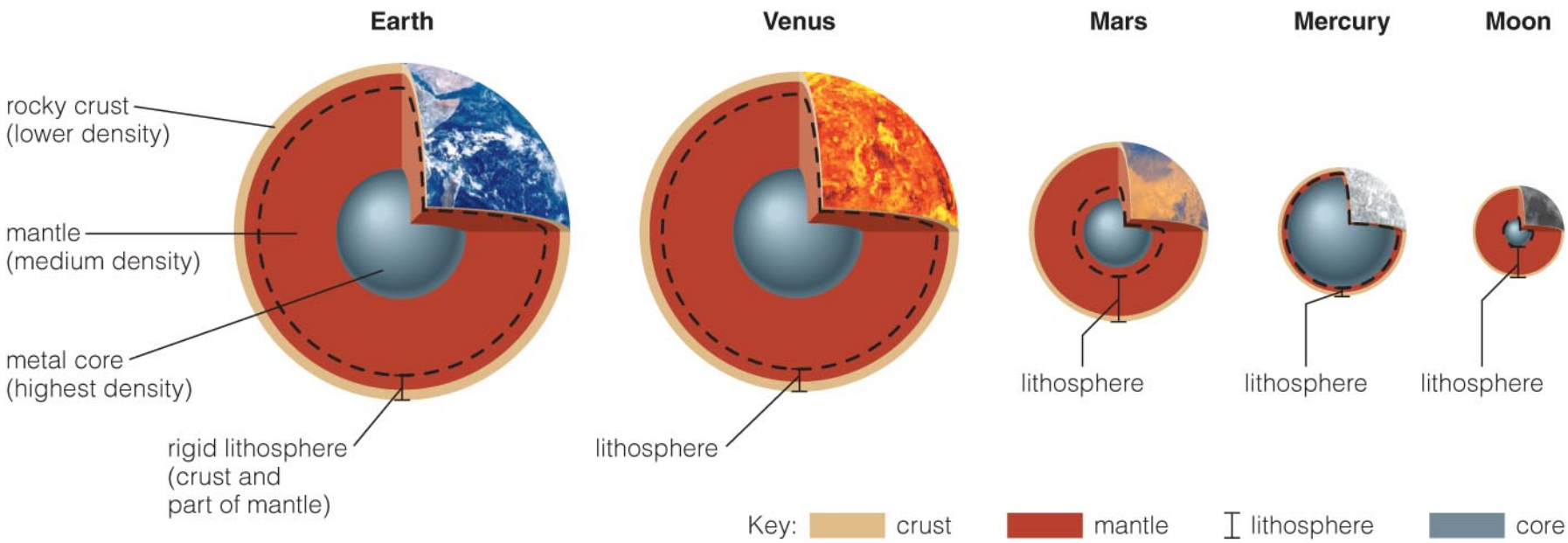
Cloud-penetrating radar revealed this twin-peaked volcano on Venus.

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

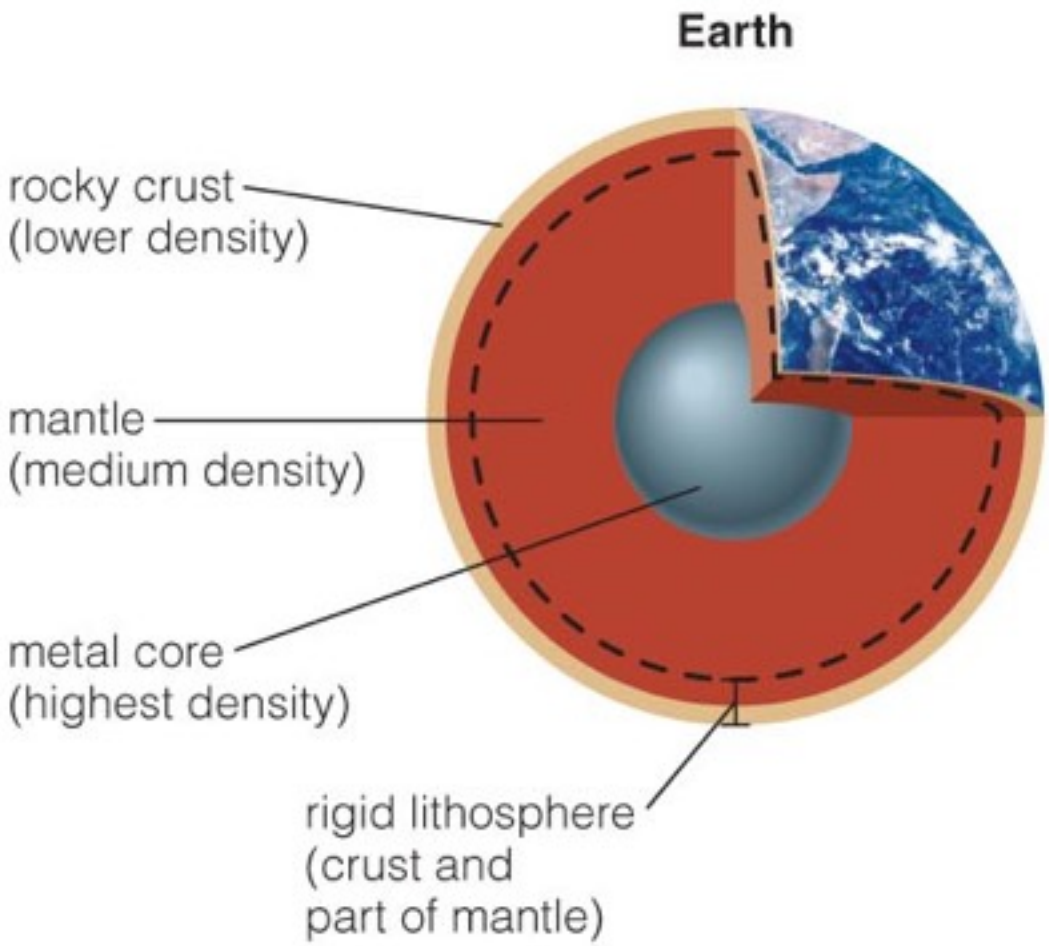
The Moon's surface is heavily cratered in most places.

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

Planetary surfaces & interiors

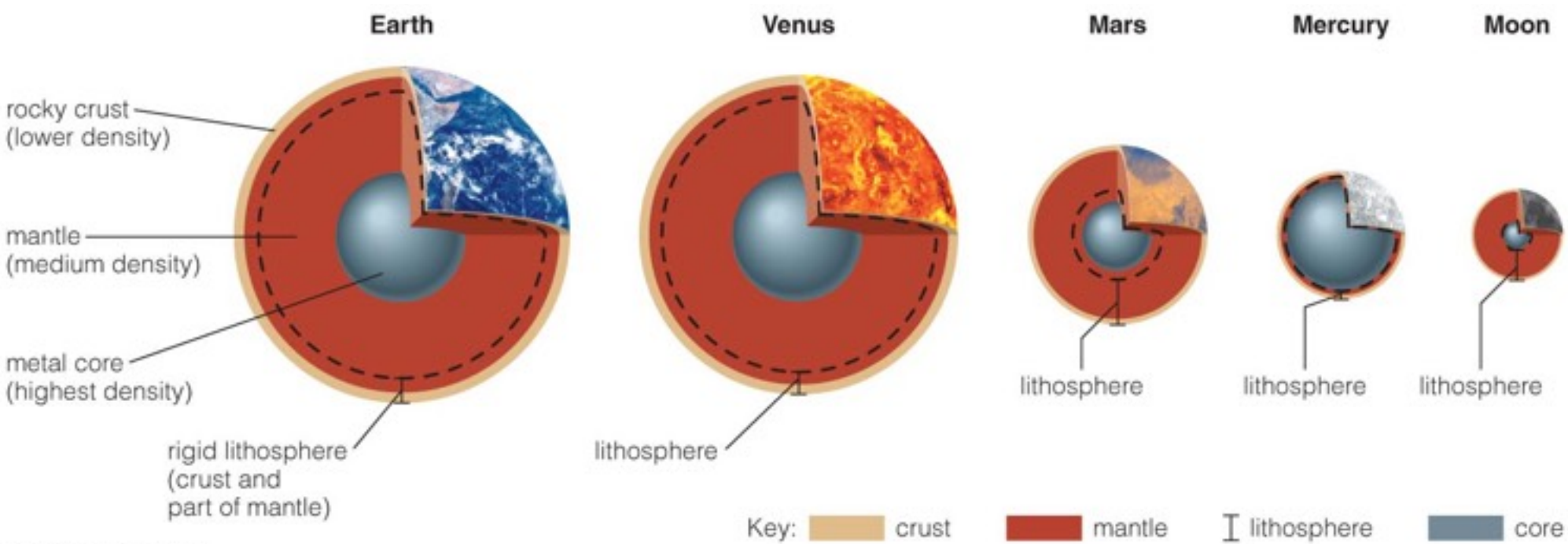


Earth's Interior



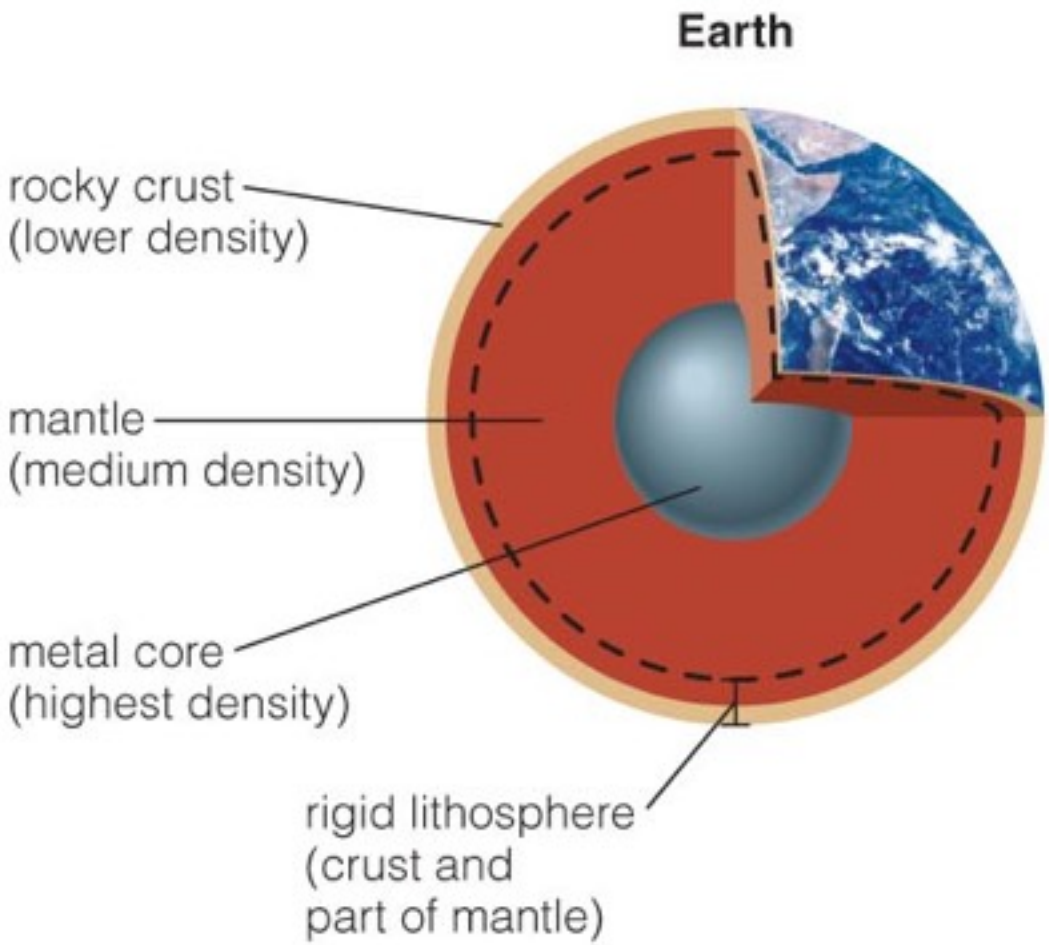
- Core: highest density; nickel and iron
- Mantle: moderate density; silicon, oxygen, etc.
- Crust: lowest density; granite, basalt, etc.

Terrestrial Planet Interiors



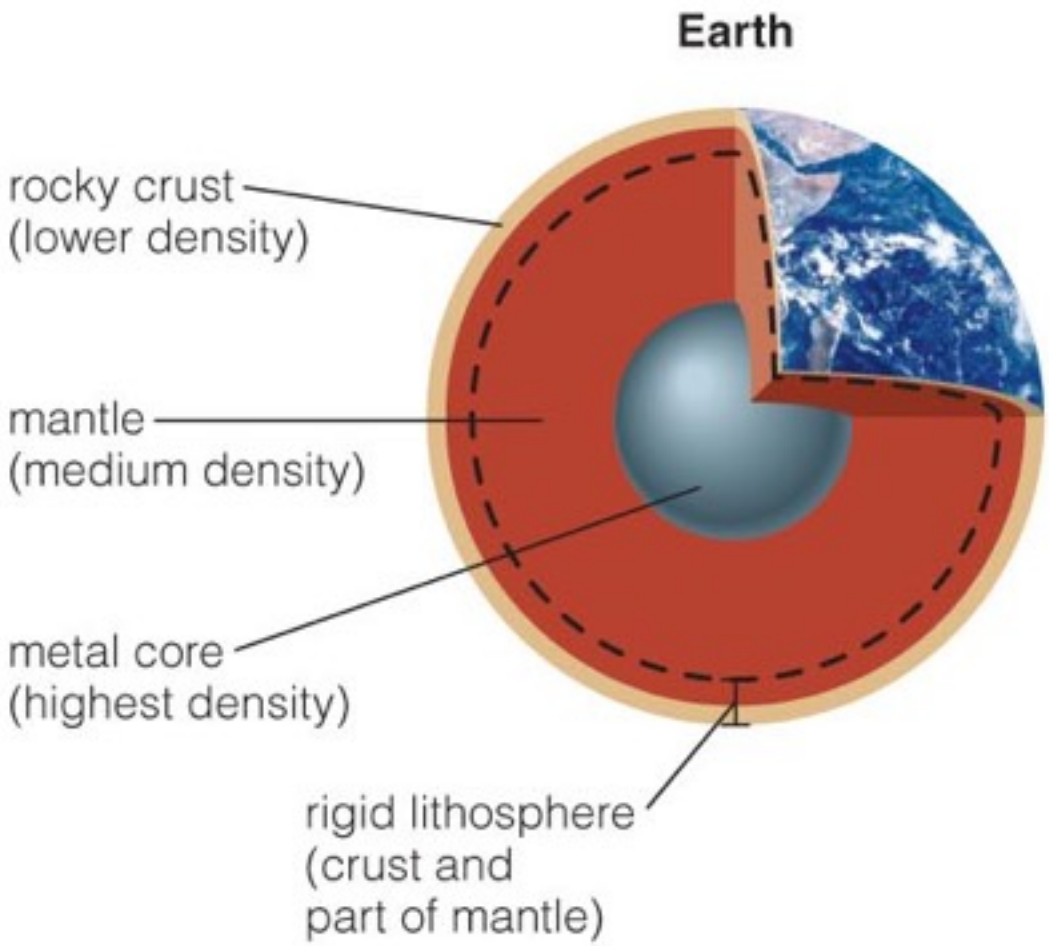
- Applying what we have learned about Earth's interior to other planets tells us what their interiors are probably like.

Differentiation



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

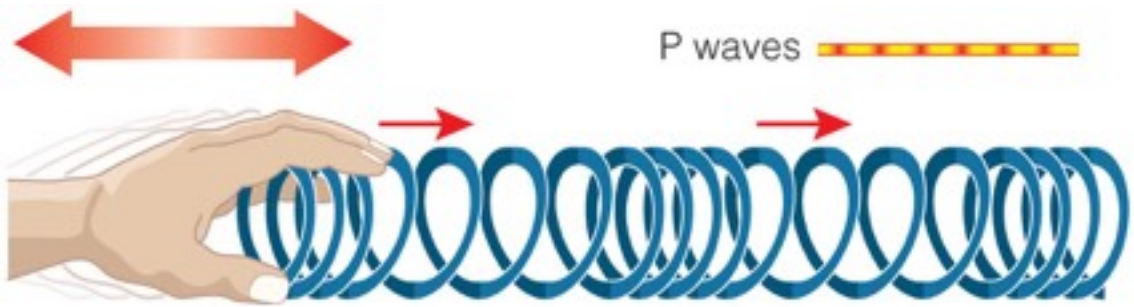
Lithosphere



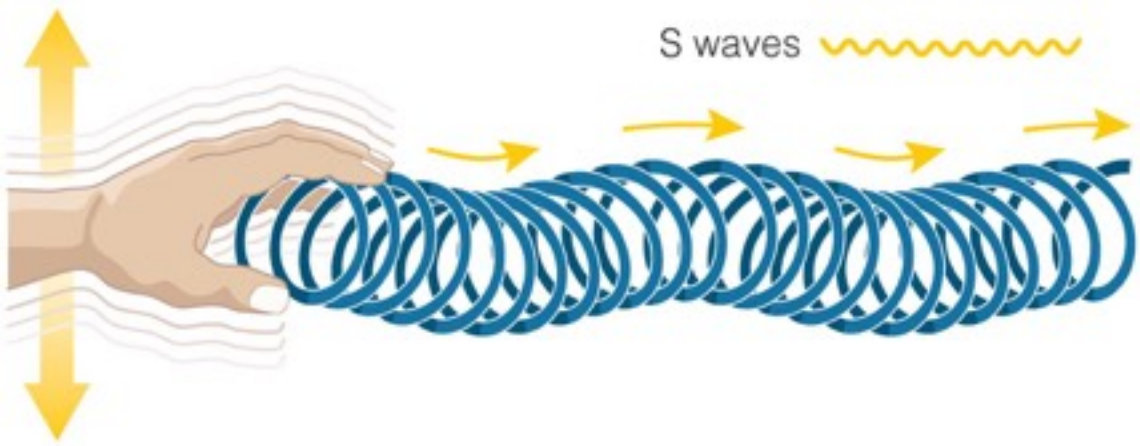
- A planet's outer layer of cool, rigid rock is called the lithosphere.
- It "floats" on the warmer, softer rock that lies beneath.

Special Topic:

How do we know what's inside Earth?

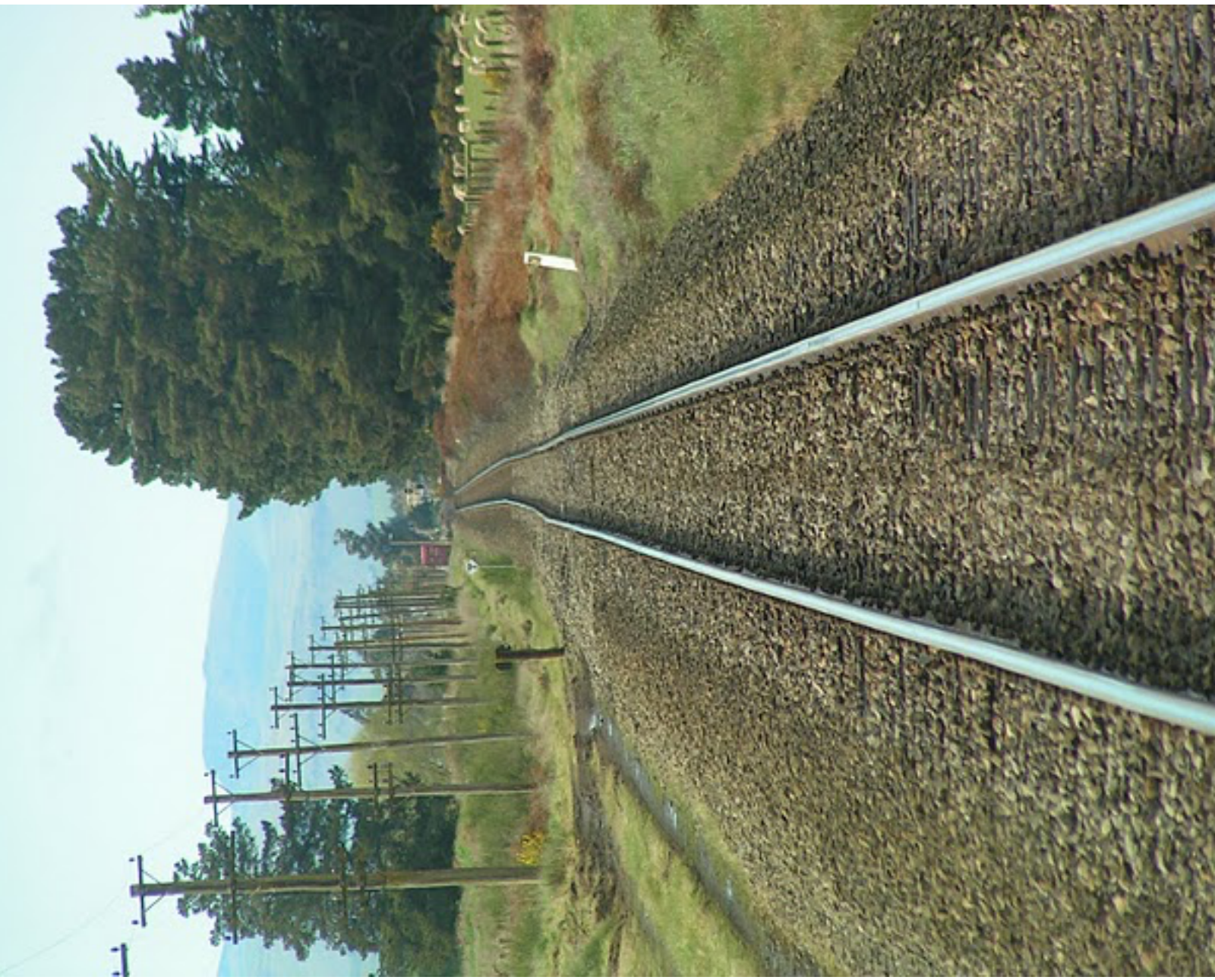


- P waves push matter back and forth.



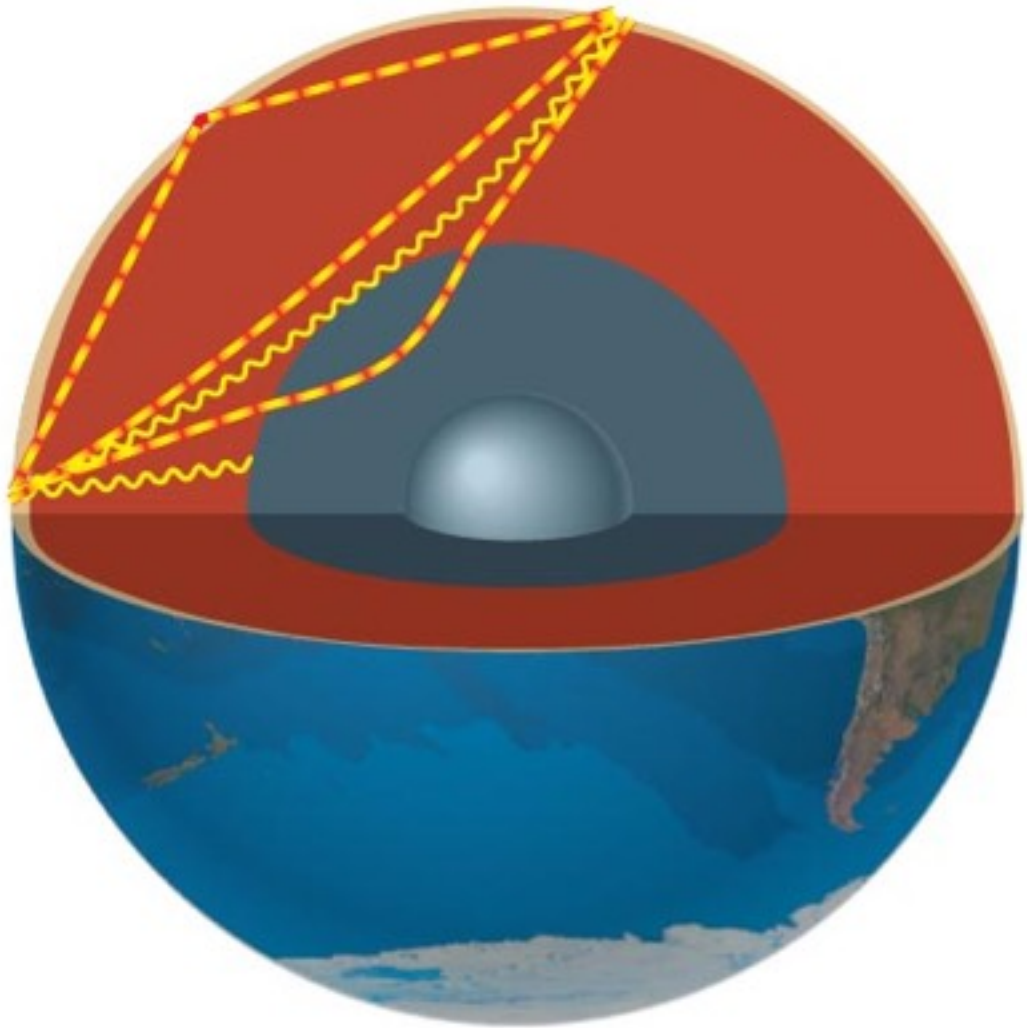
- S waves shake matter side to side

4 September 2010 mag. 7.1 Canterbury earthquake in New Zealand.



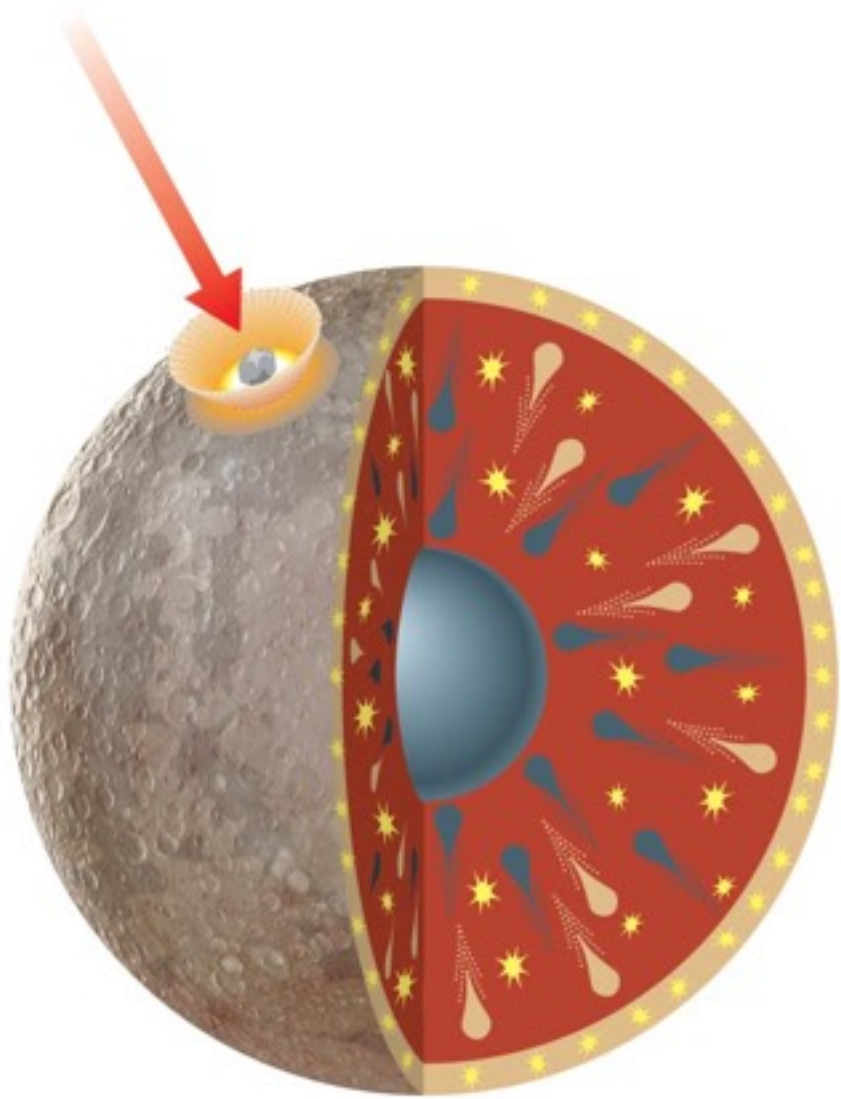
Special Topic:

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.

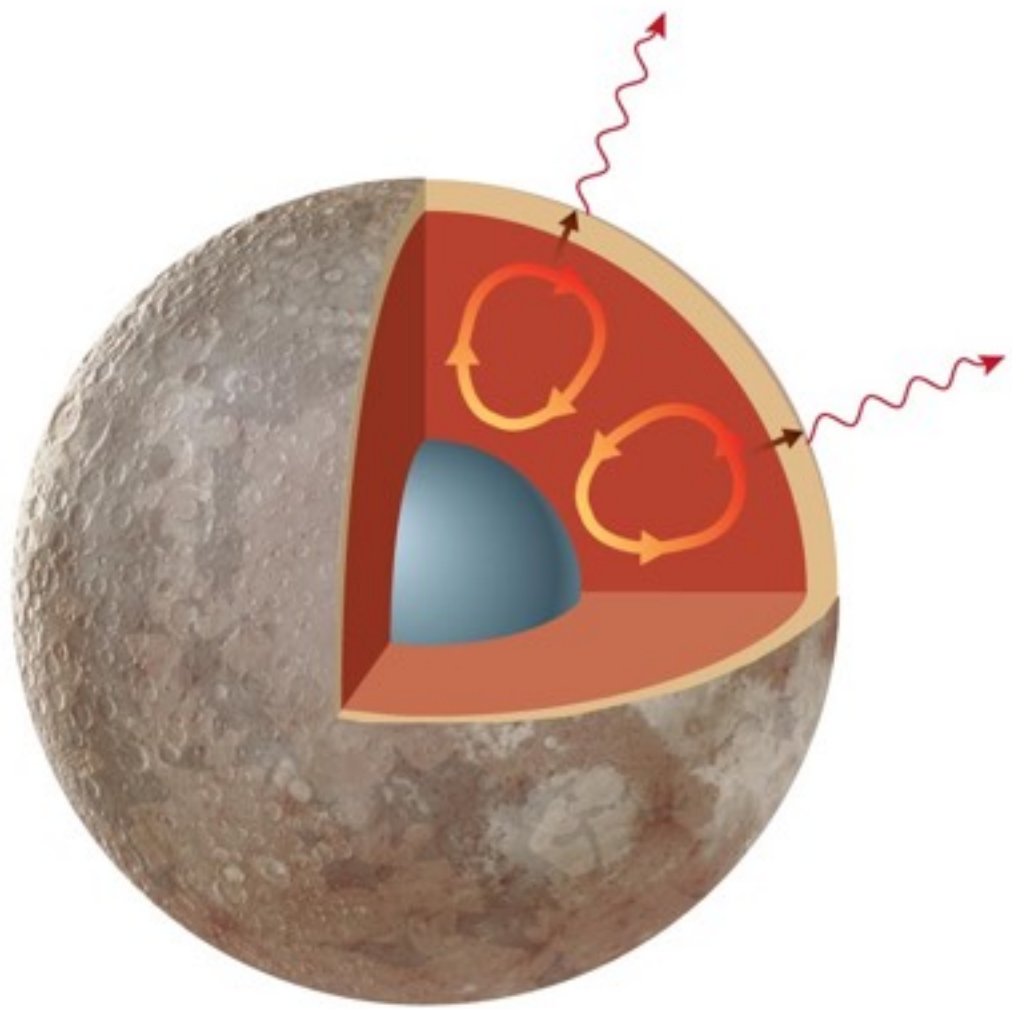
Heating of Planetary Interiors



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

Heat drives geological activity

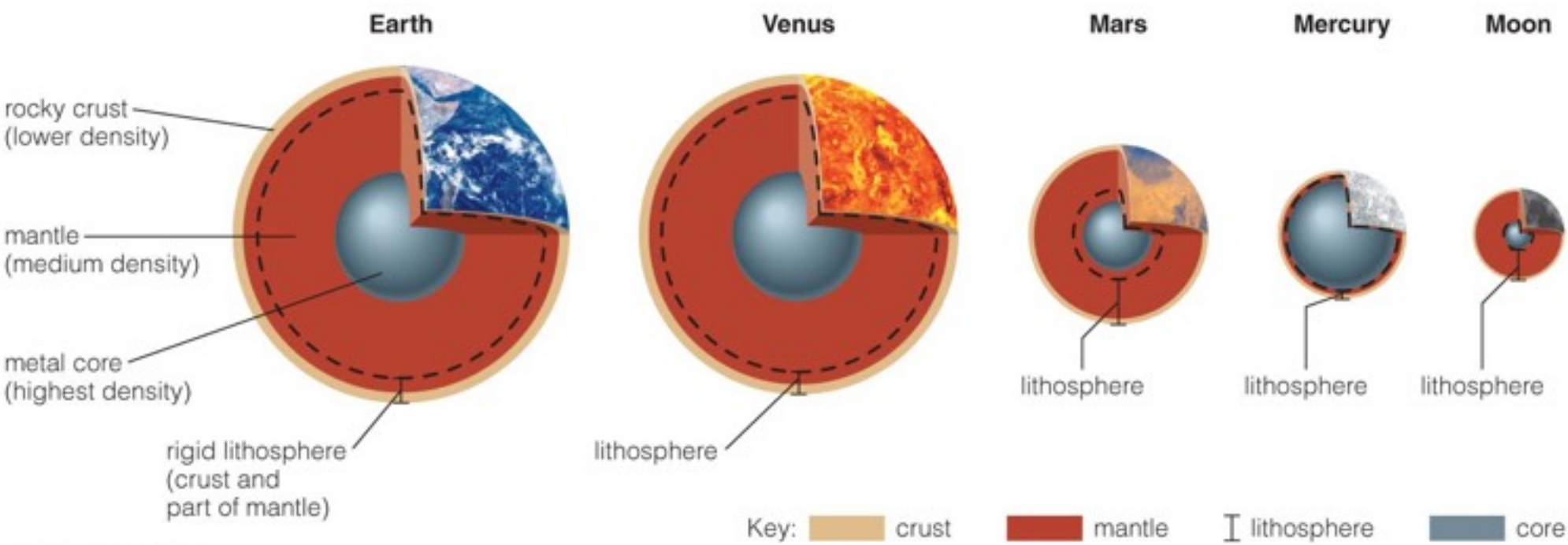
Cooling of Planetary Interiors



- 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.

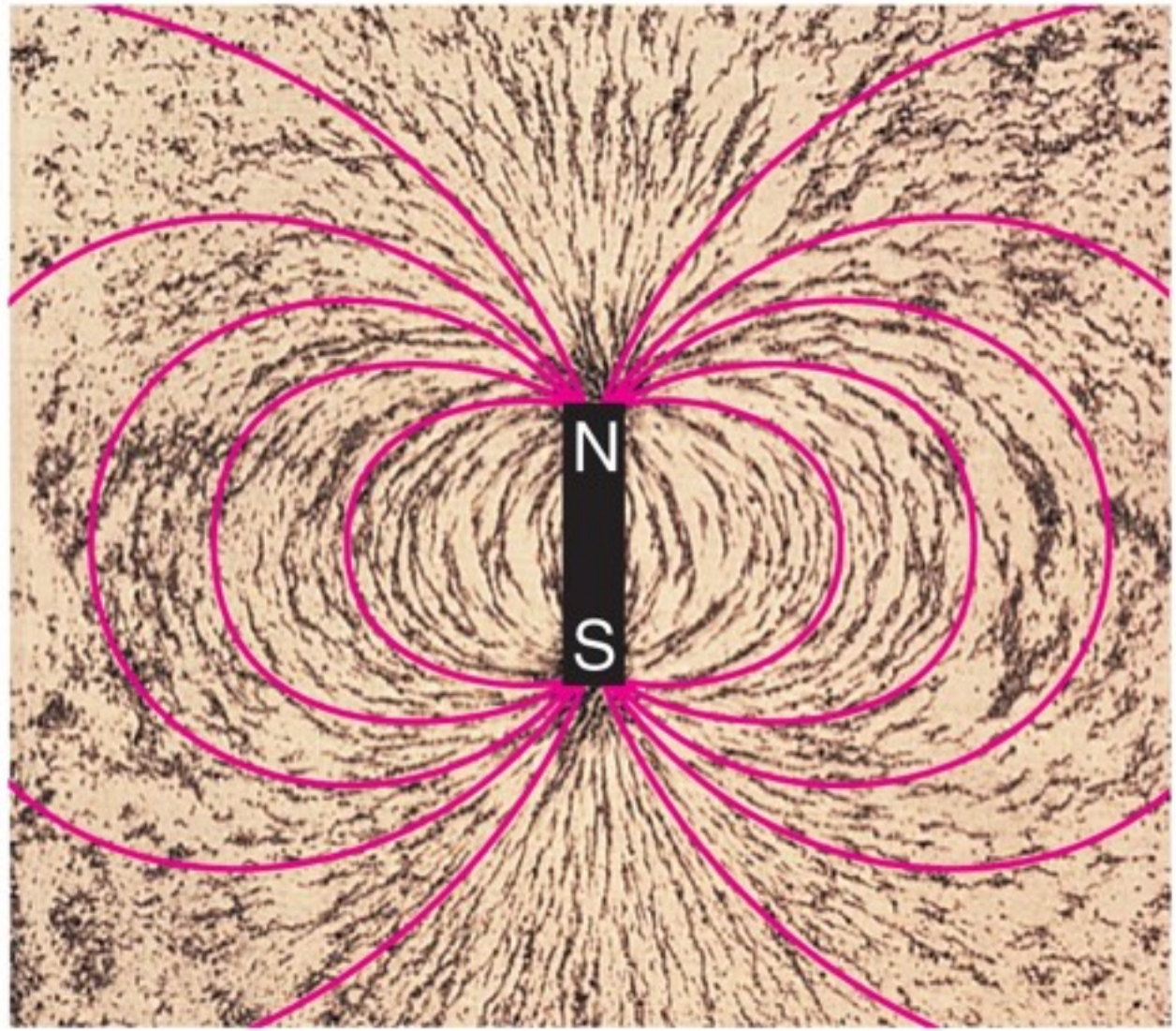
Heat drives geological activity

Role of Size

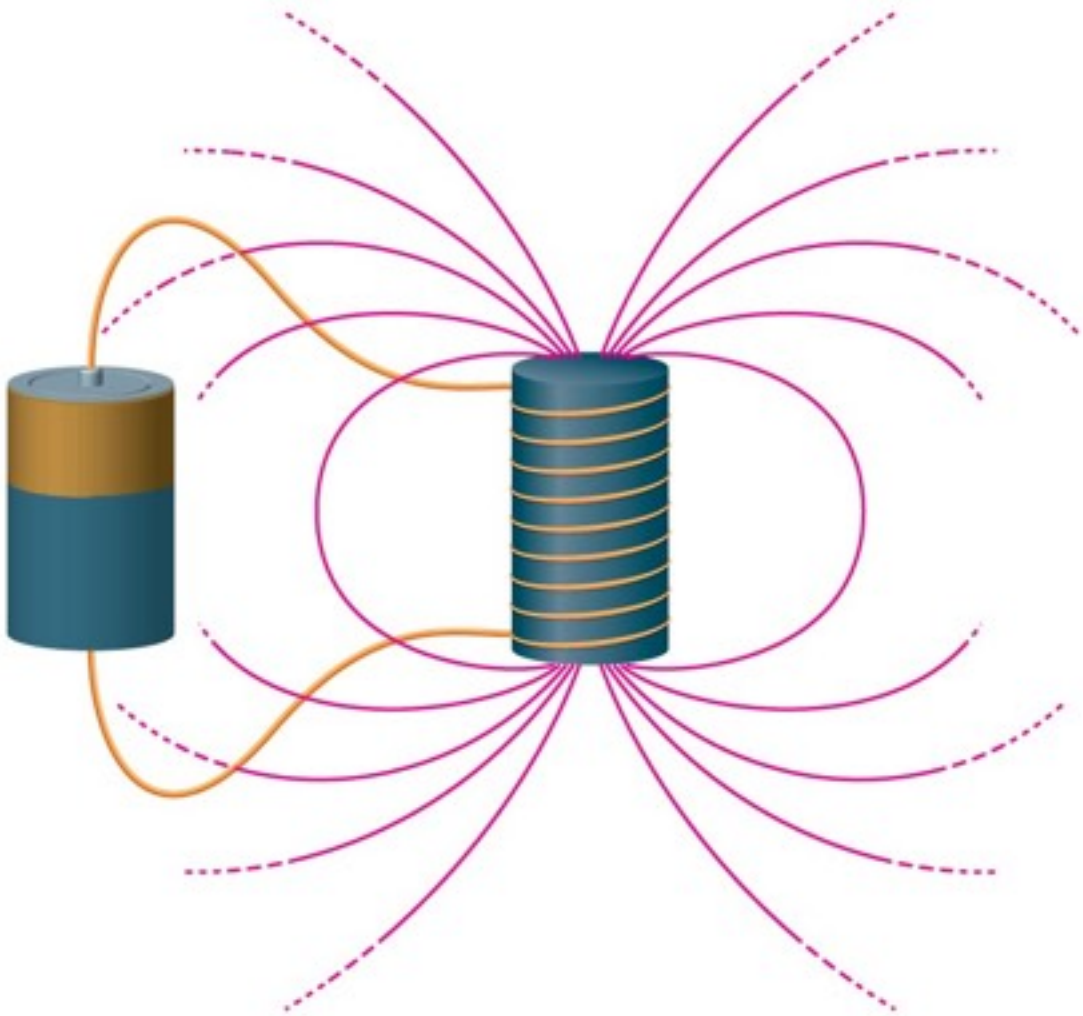


- Smaller worlds cool off faster and harden earlier.
  - cooling time depends on surface area/volume ratio
- The Moon and Mercury are now geologically "dead."

Why do some planetary interiors create magnetic fields?

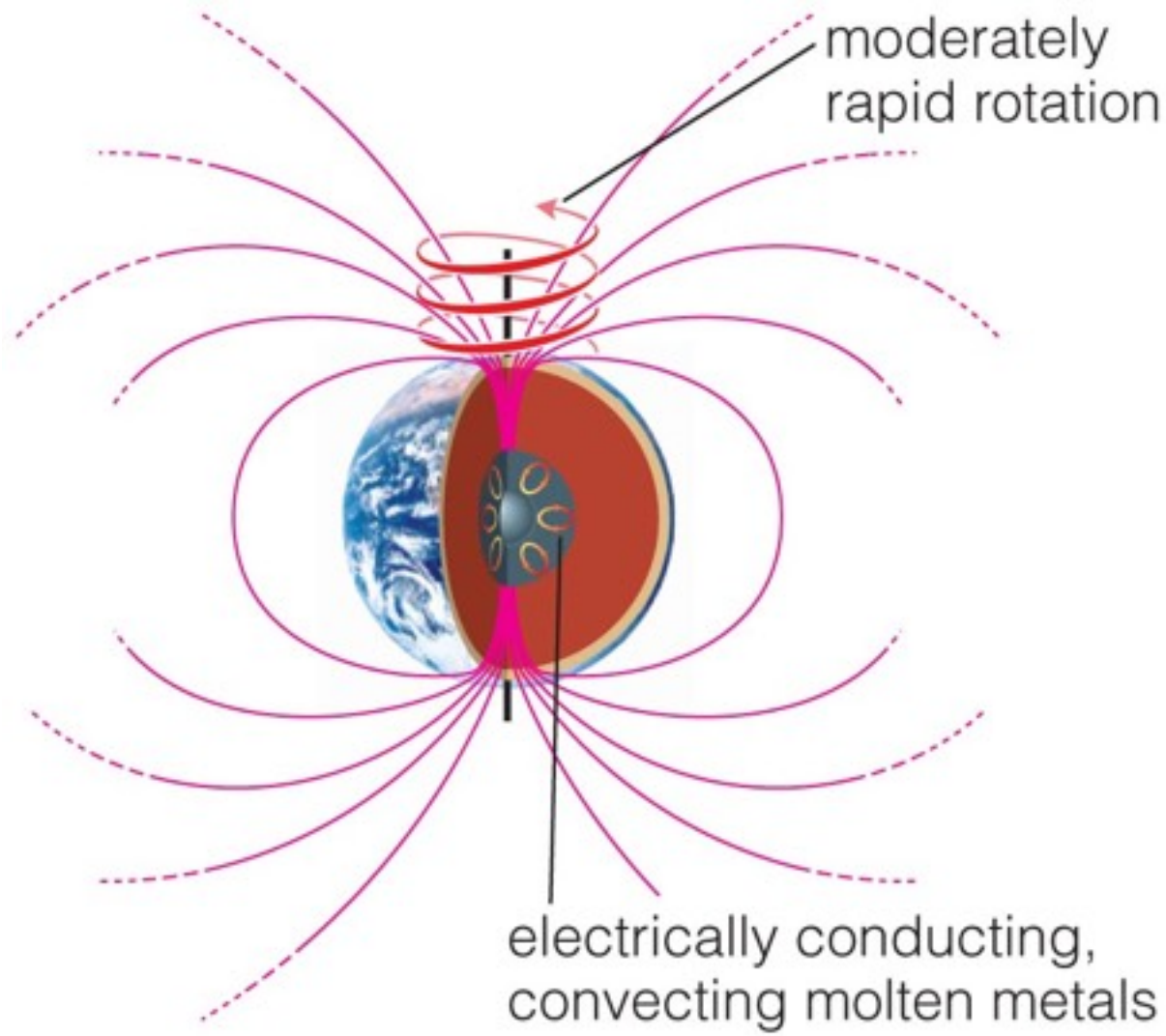


Sources of Magnetic Fields



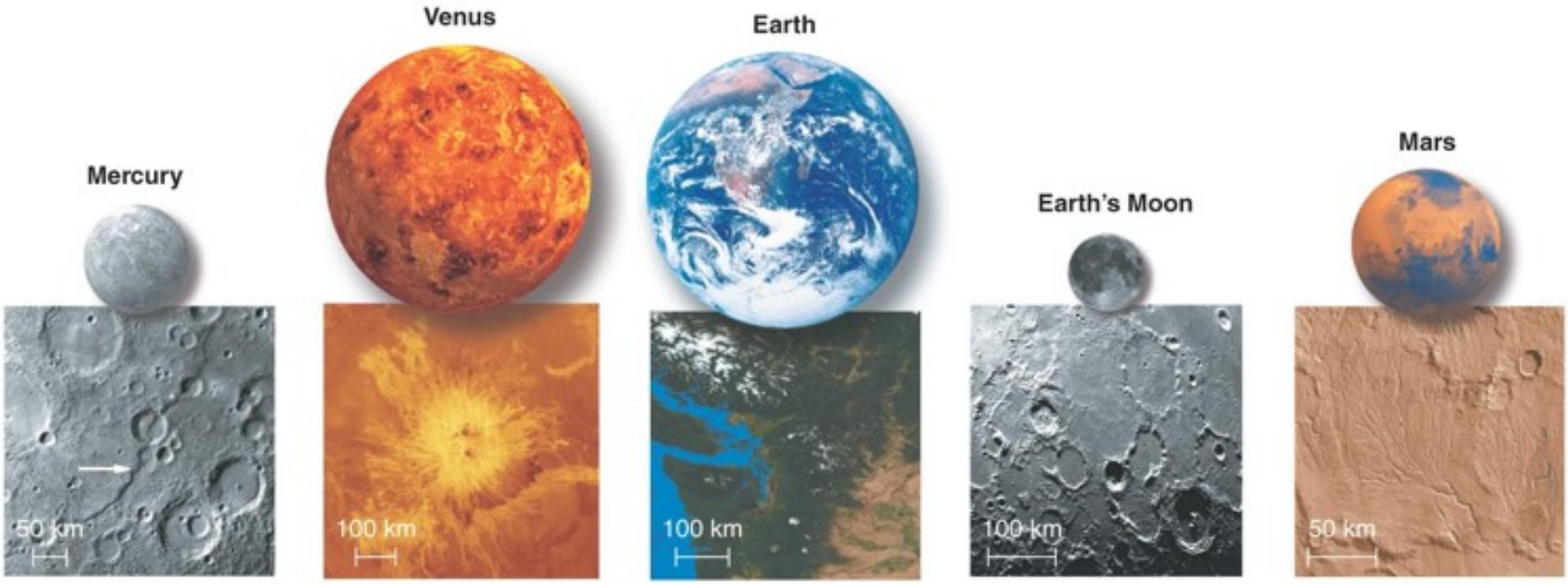
- Motions of charged particles create magnetic fields.

Sources of Magnetic Fields



- A world can have a magnetic field if charged particles are moving inside.
- Three requirements:
  - Molten, electrically conducting interior
  - Convection
  - Moderately rapid rotation

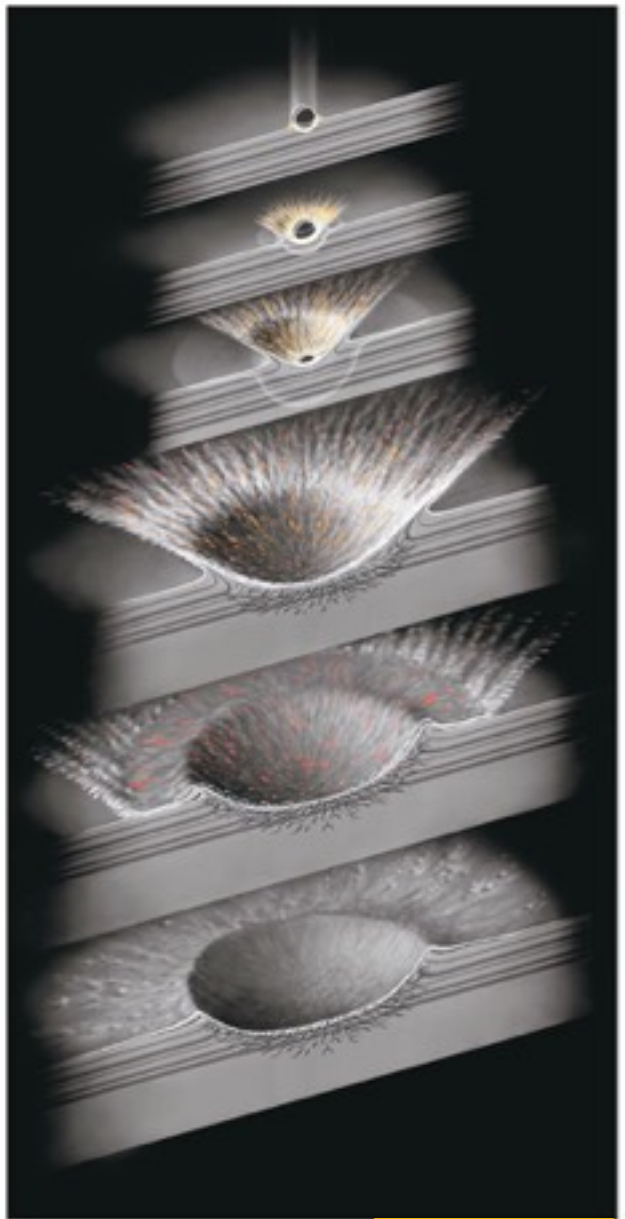
What processes shape planetary surfaces?



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



- 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.

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

Meteor Crater (Arizona)

Tycho Crater (Moon)

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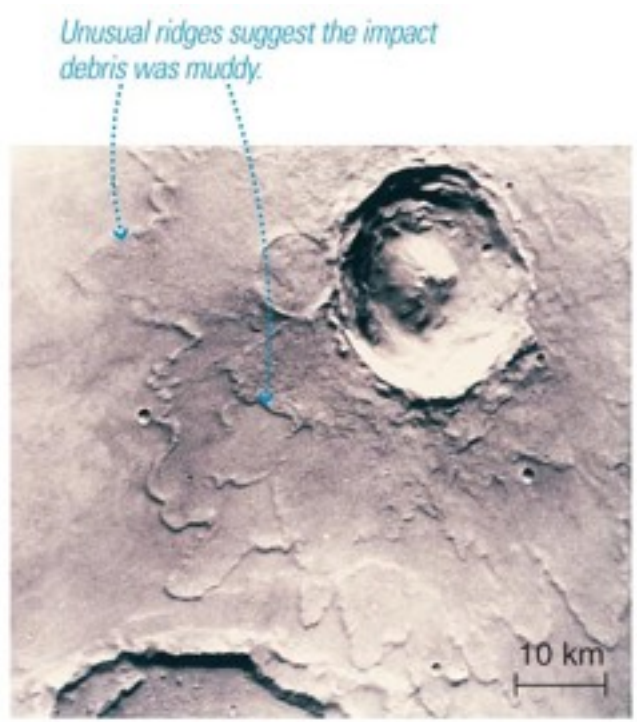
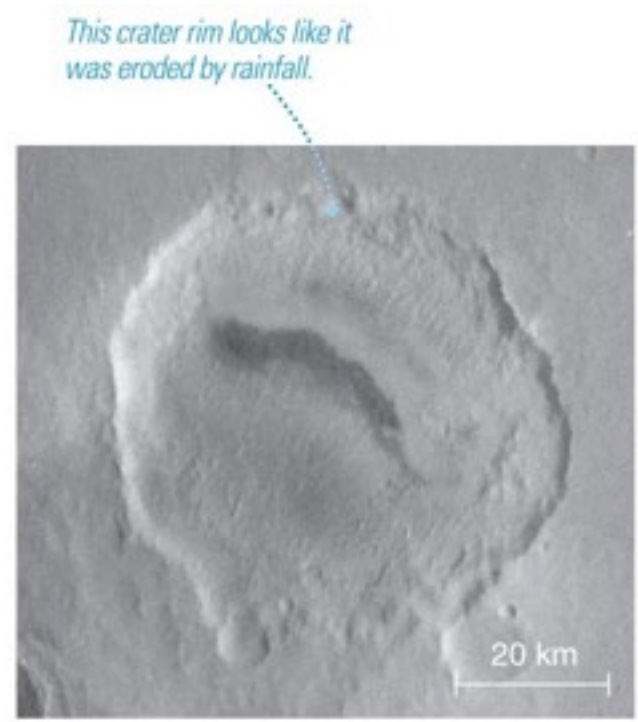
Impact Craters on Mars

a A crater with a typical bowl shape.



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



c This crater shows evidence of erosion.

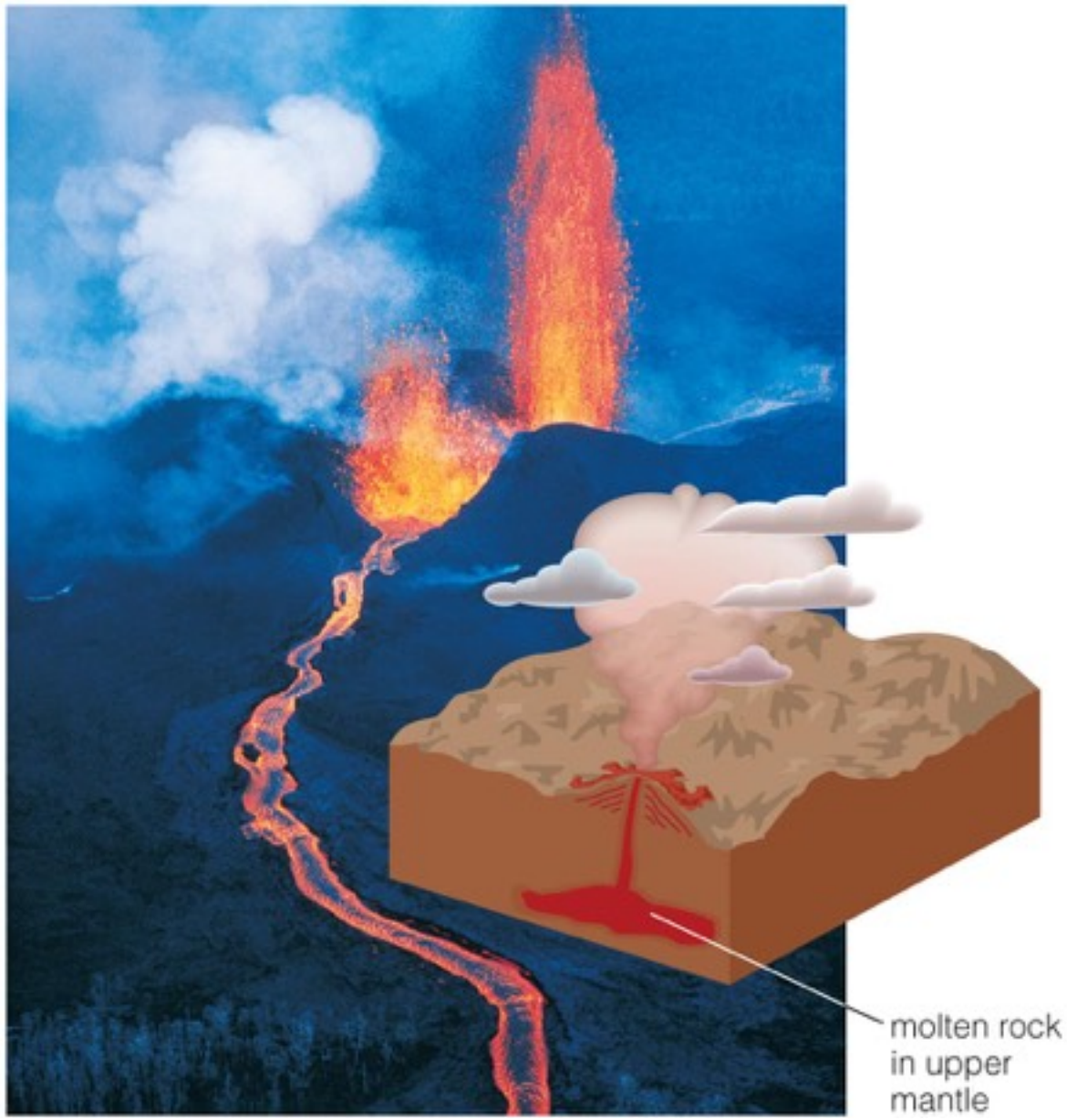
"Standard" crater

Impact into icy ground

Eroded crater

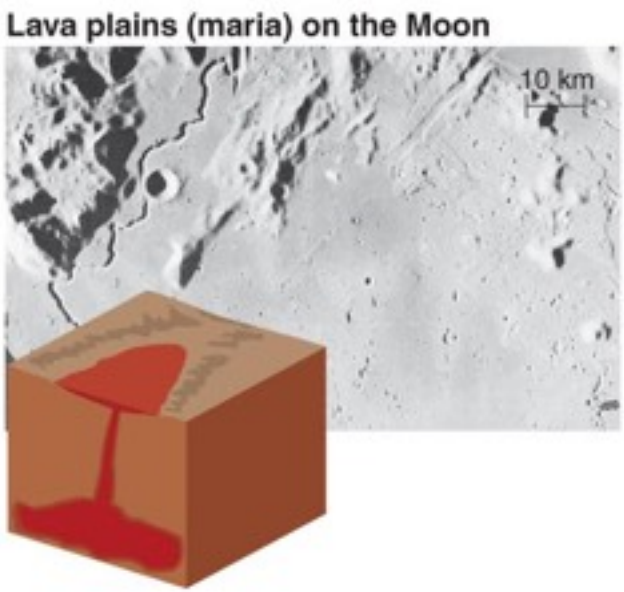
water droplet/granite sphere videos

Volcanism

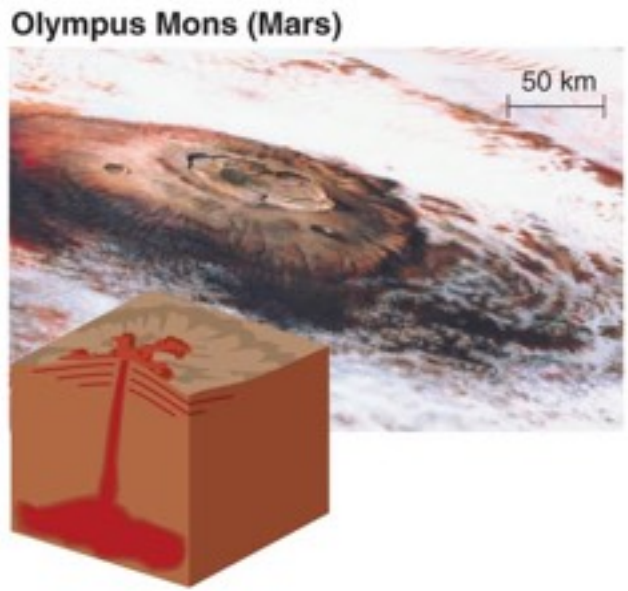


- Volcanism happens when molten rock (magma) finds a path through lithosphere to the surface.
- Molten rock is called lava after it reaches the surface.

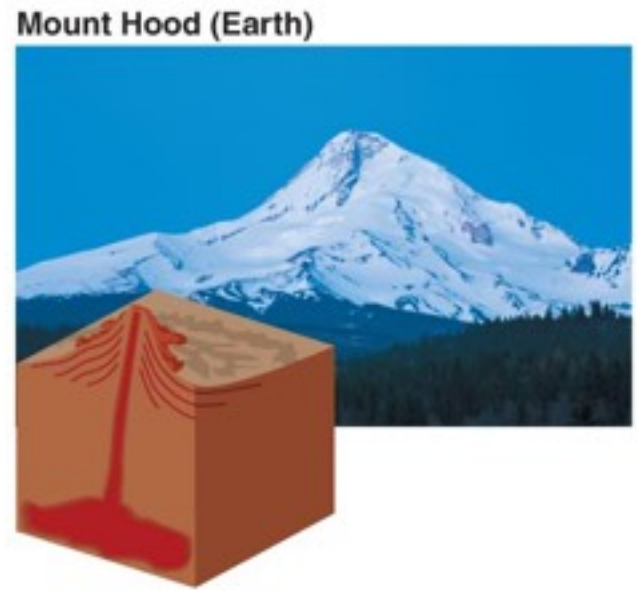
Lava and Volcanoes



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.



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



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

Runny lava makes flat lava plains.

Slightly thicker lava makes broad shield volcanoes.

Thickest lava makes steep stratovolcanoes.

Iceland's Bardabunga eruption

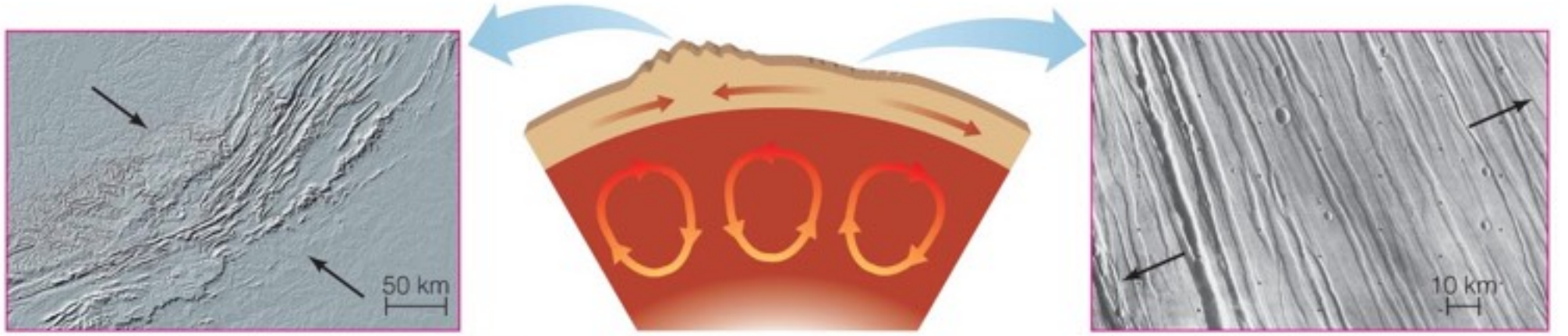
Outgassing

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.

Tectonics



Appalachian Mountains in eastern United States

Ceraunius Valleys on Mars

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.

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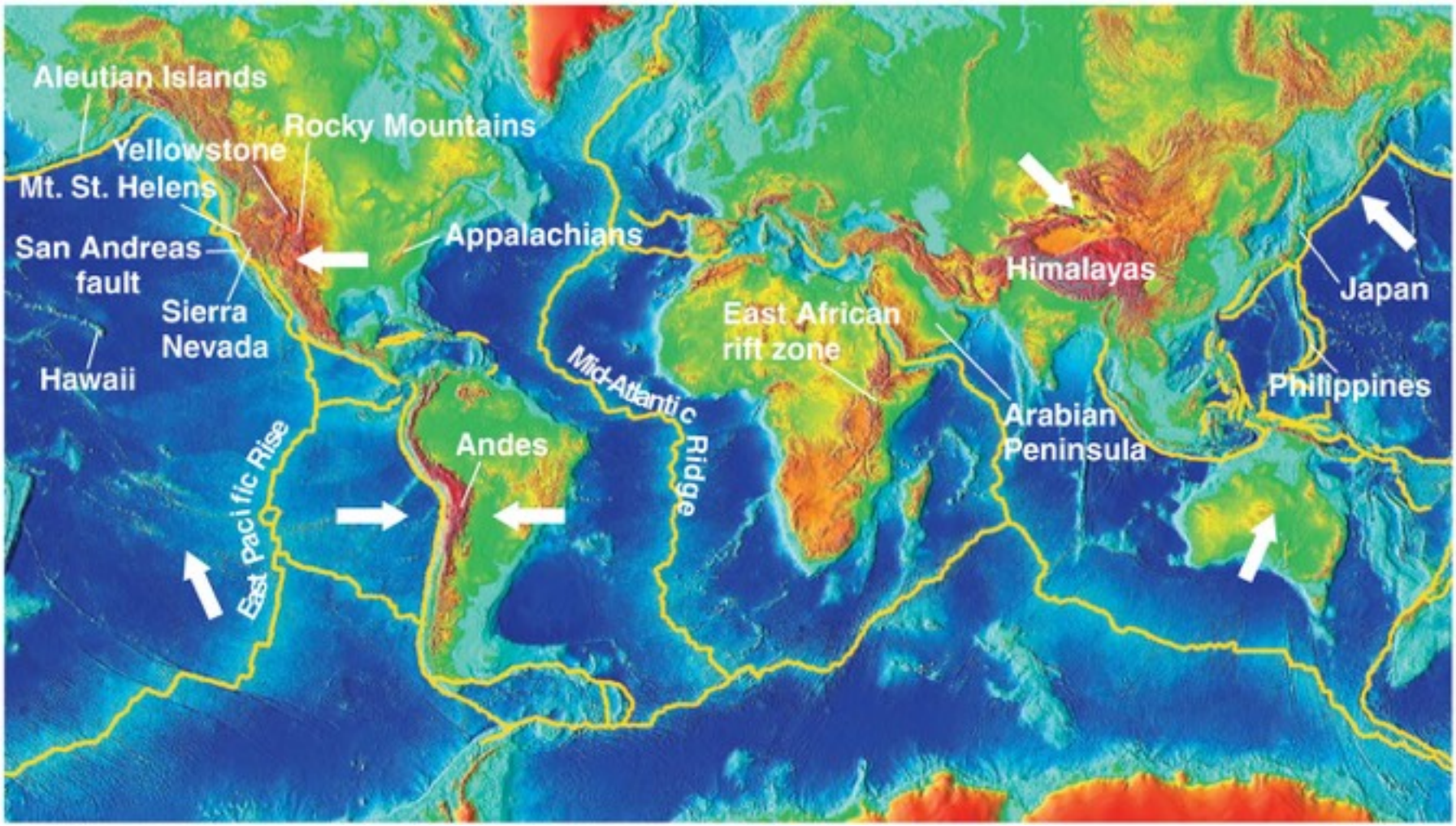
Plate Tectonics on Earth

- 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.