

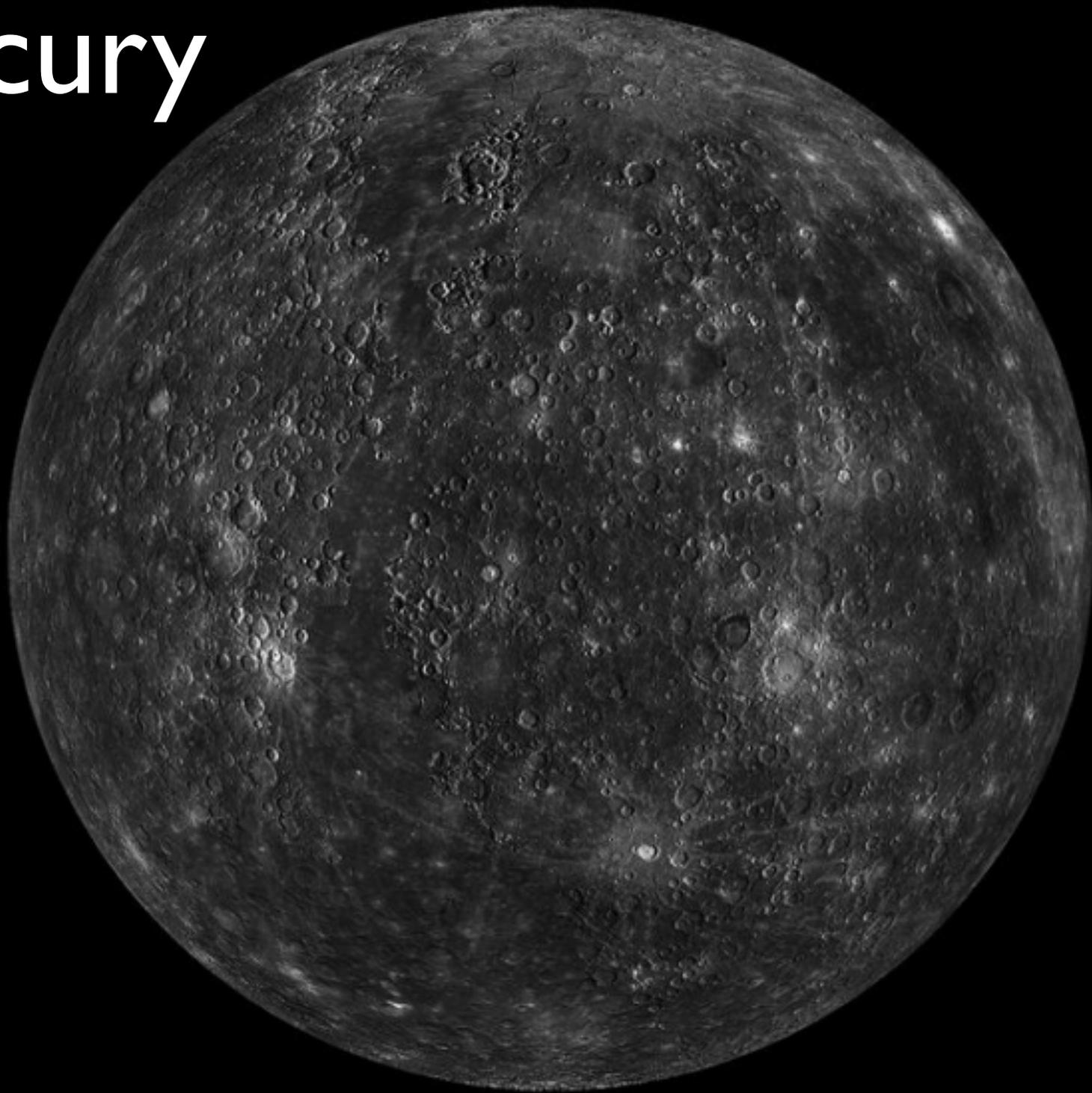
Today

- Terrestrial Planet Geology
- individual cases

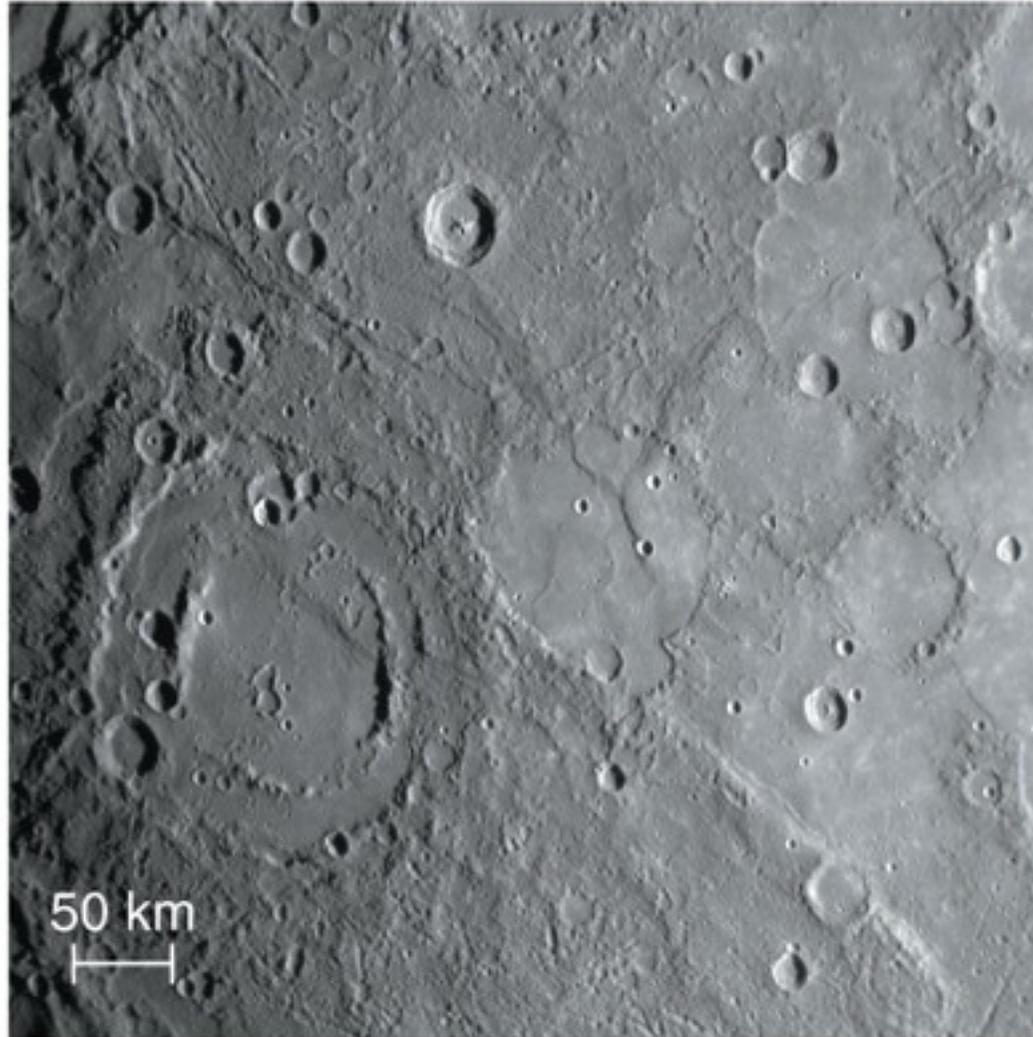
Events

- Spring break next week

Mercury

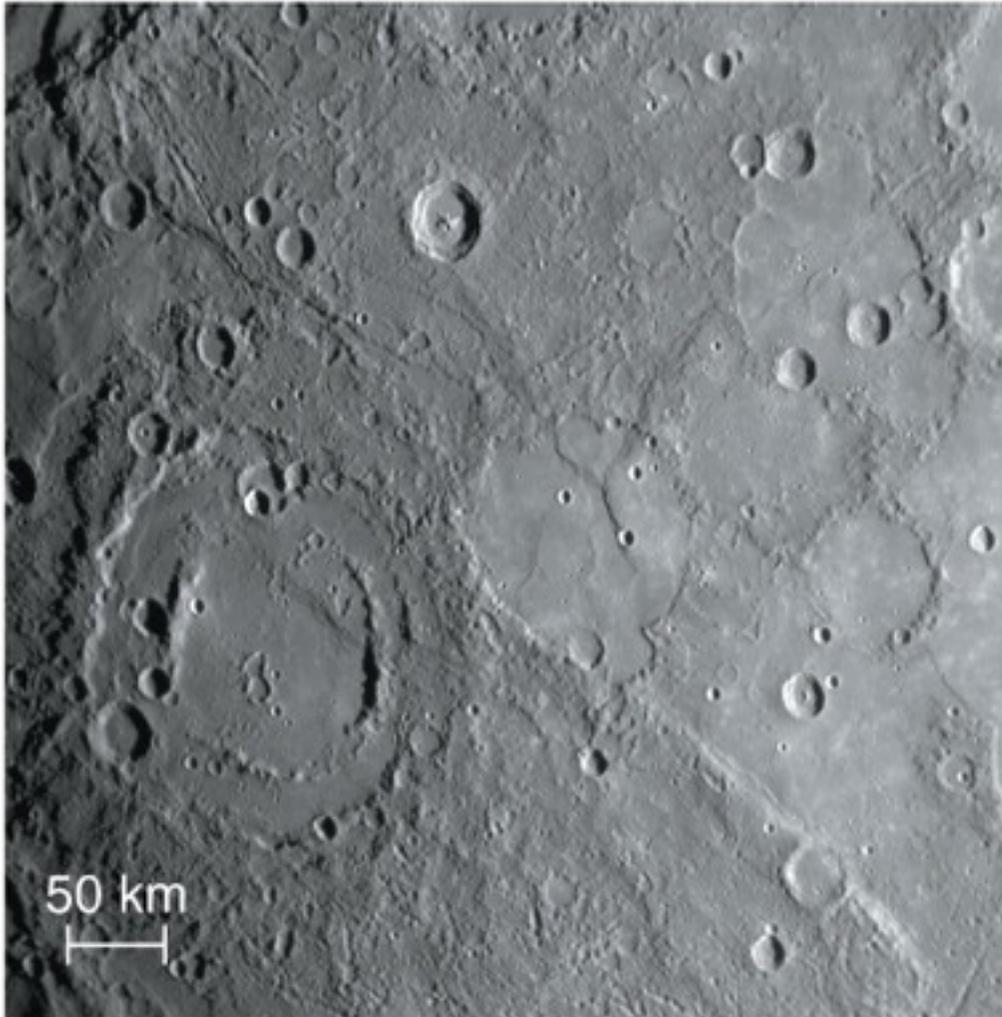


What geological processes shaped Mercury?



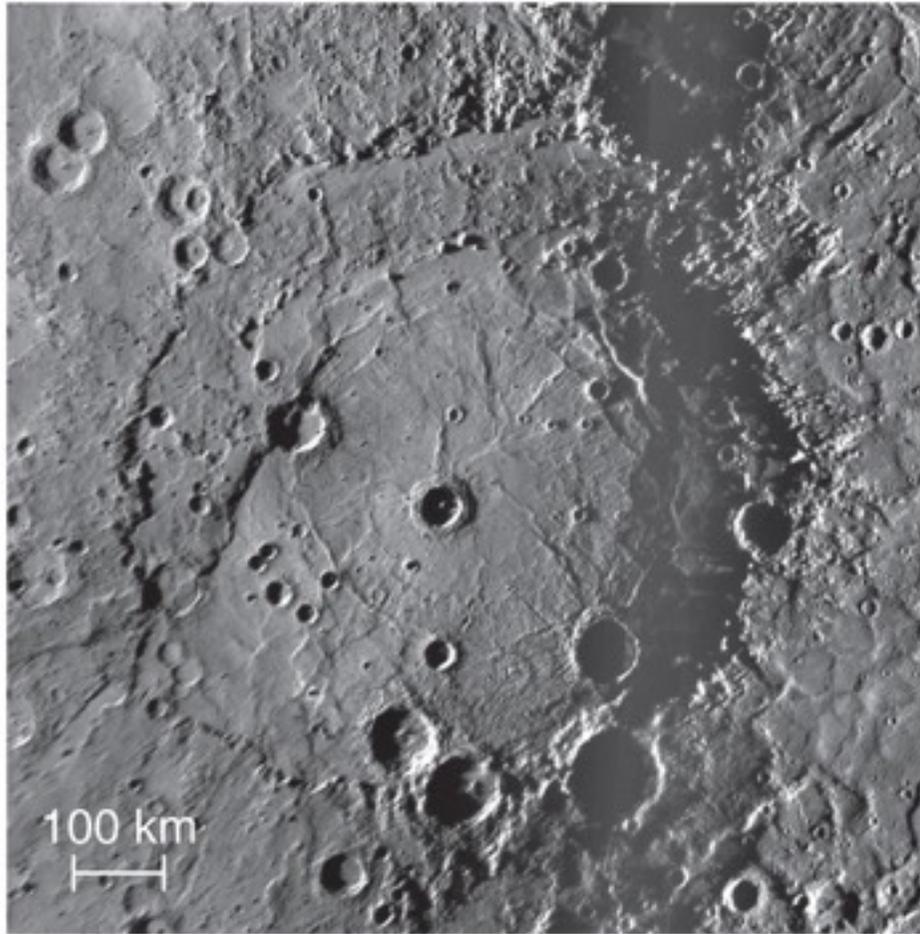
a A close-up view of Mercury's surface, showing impact craters and smooth regions where lava apparently covered up craters.

Cratering of Mercury

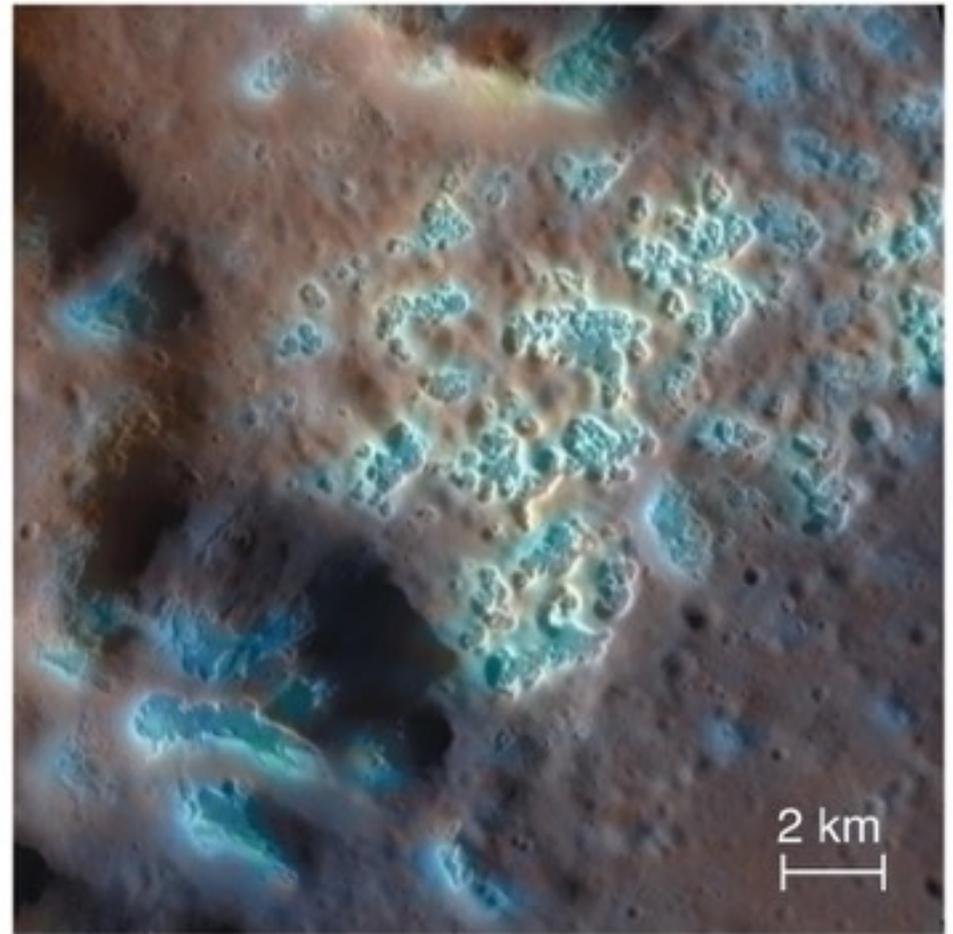


- Mercury has a mixture of heavily cratered and smooth regions like the Moon.
- Smooth regions are likely ancient lava flows.

Cratering of Mercury



The Rembrandt Basin is a large impact crater on Mercury.



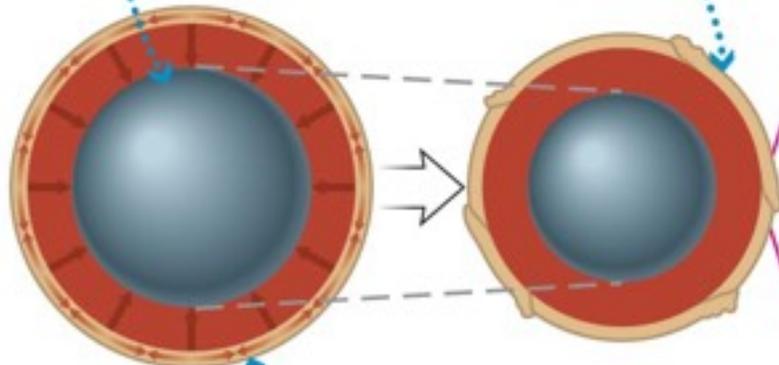
Hollows in a crater floor created by escaping gases.

Tectonics on Mercury

Scarps

Mercury's core and mantle shrank . . .

Some portions of the crust were forced to slide under others.



. . . causing Mercury's crust to contract.

Not to scale!

Today we see long, steep cliffs created by this crustal movement.



- Long cliffs (scarps) created when Mercury shrank (about 7 km in diameter) as it cooled.

MESSENGER: 10 Years in Space

BY THE NUMBERS*

8 BILLION
miles traveled

29 TRIPS
around
the Sun

255,858
IMAGES
returned to Earth

91,730 MPH
average speed
(relative to the Sun)

60 MILES
from the
surface
at closest
approach

6 FLYBYS
of the
inner planets

35 MILLION
SHOTS
by the Mercury
Laser Altimeter

7 MERCURY
SOLAR DAYS
and

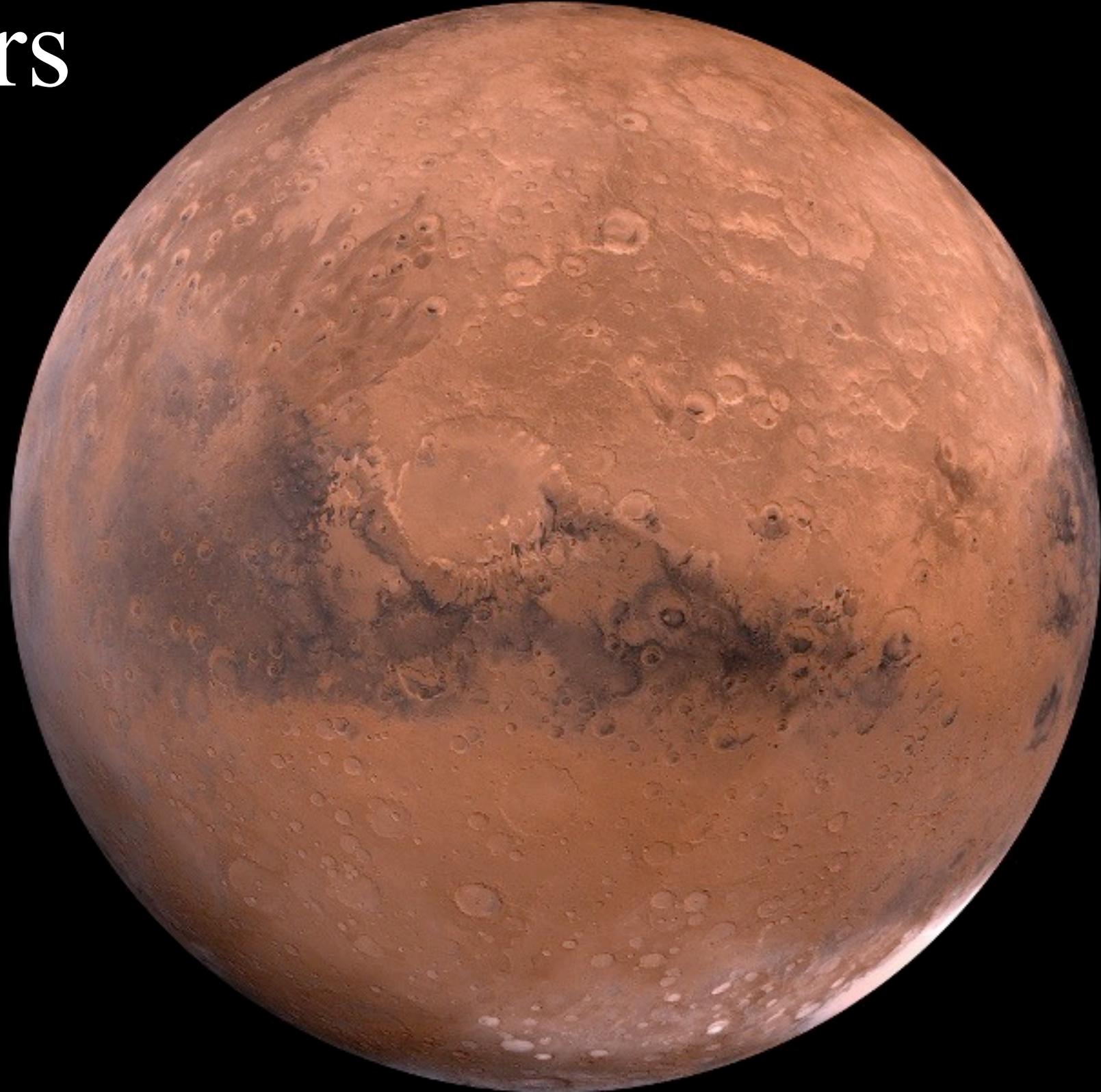
1,232 EARTH
DAYS
in orbit

3,308
ORBITS

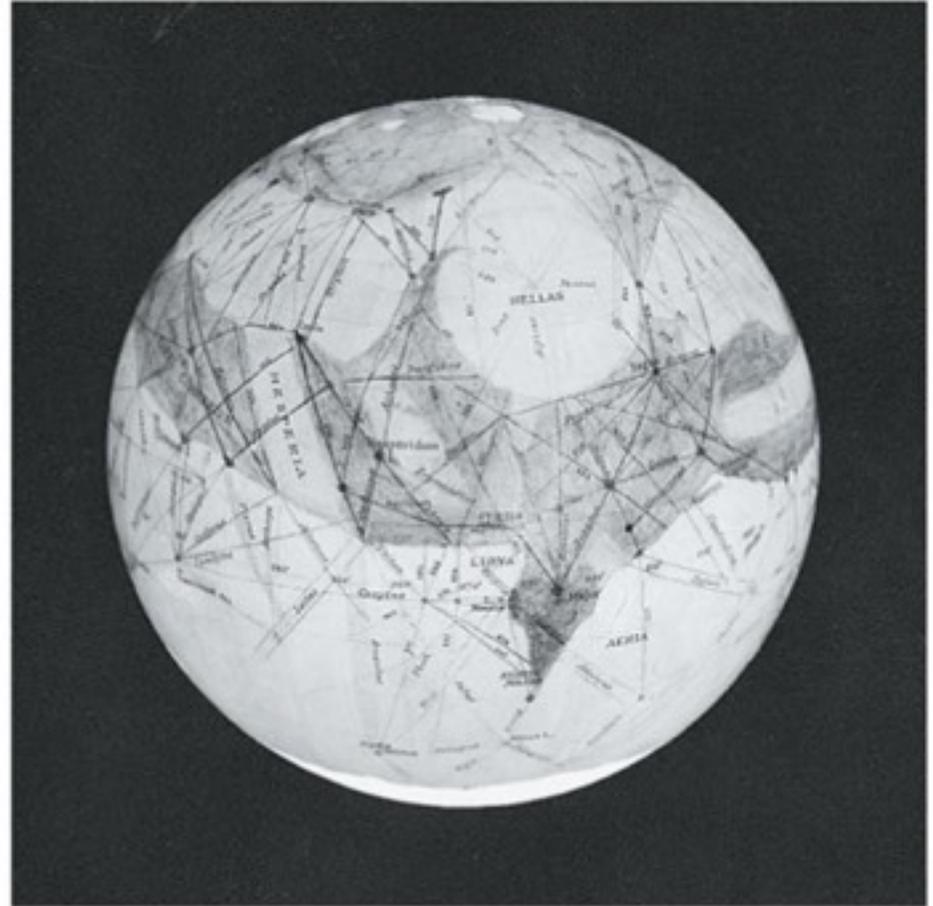
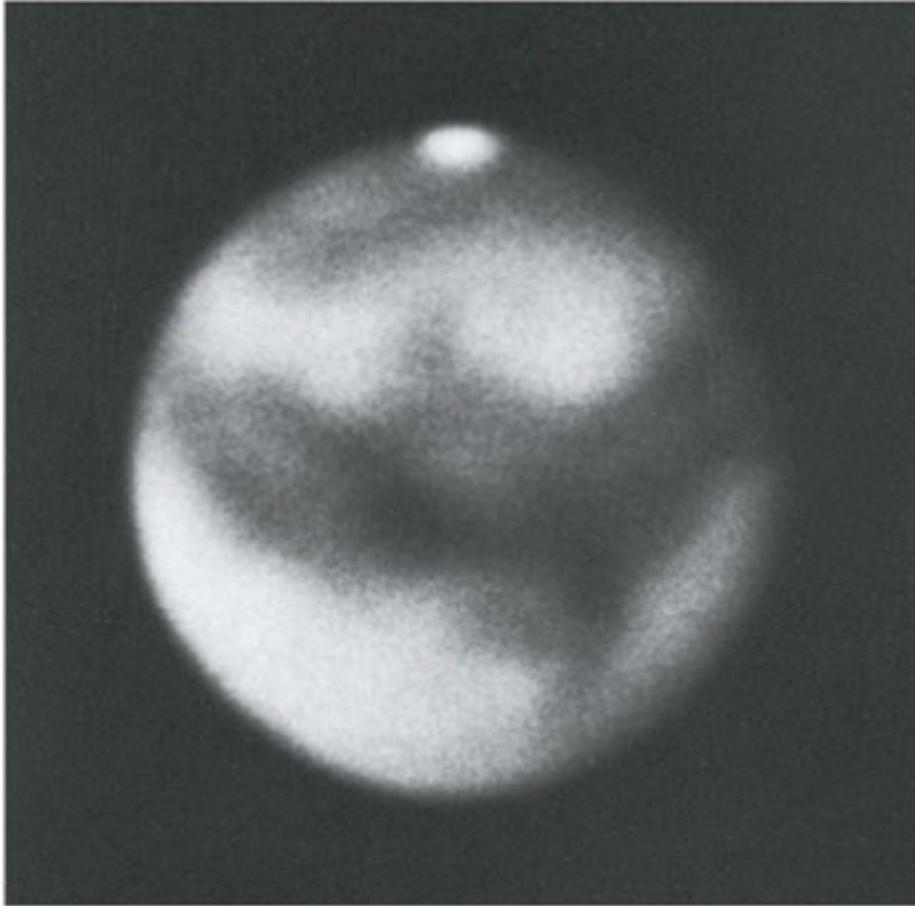


WILL CRASH SOON

Mars

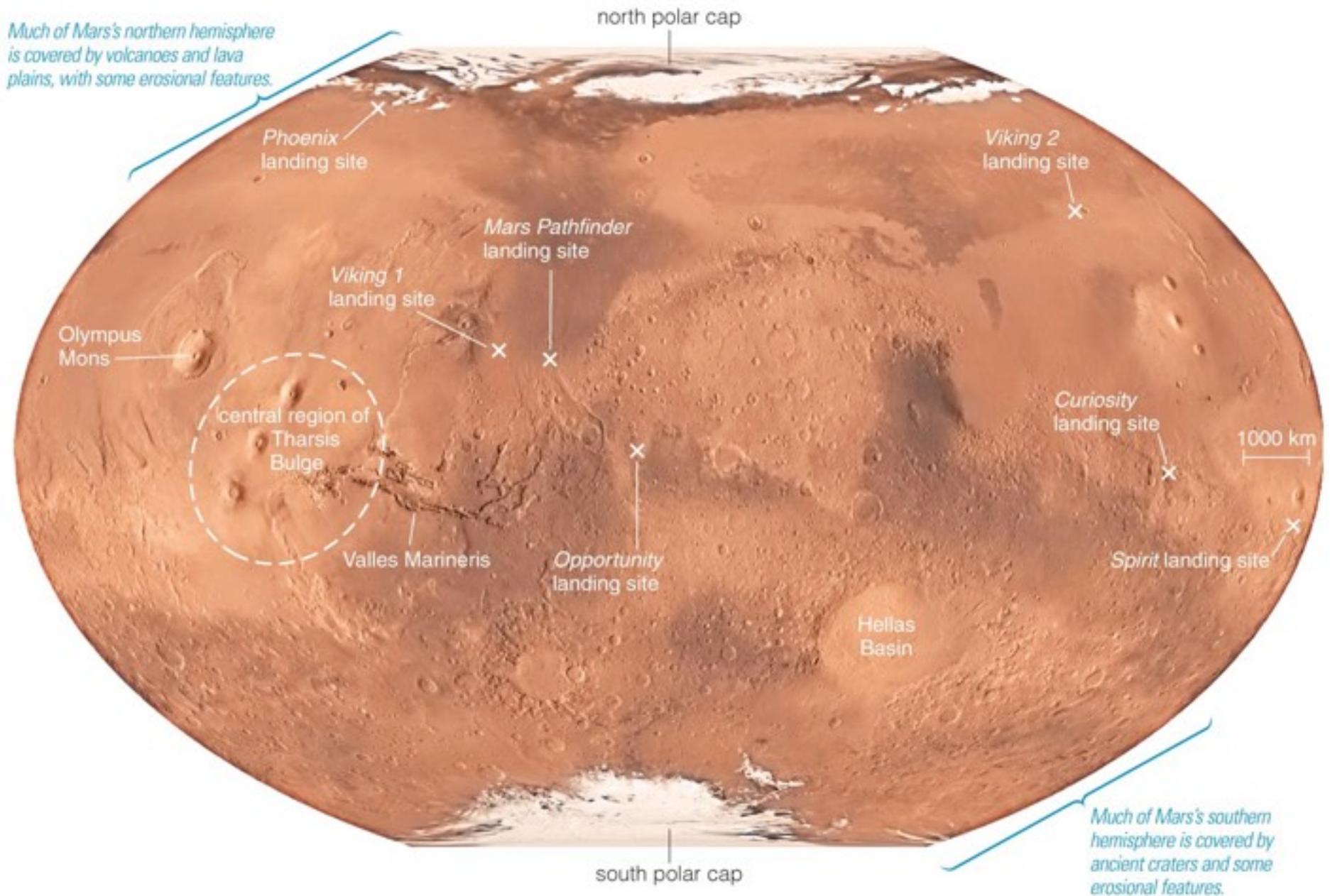


"Canals" on Mars

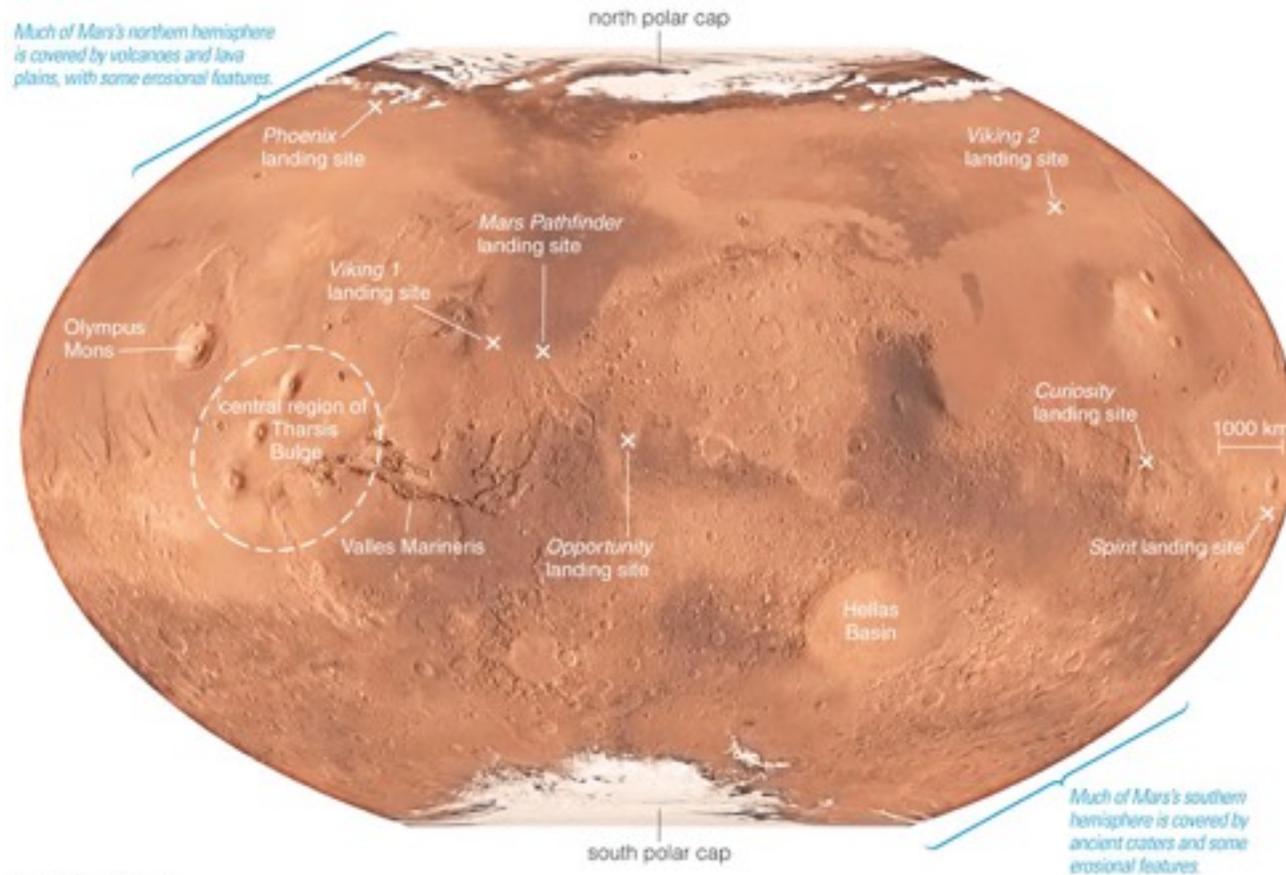


- Percival Lowell misinterpreted surface features seen in telescopic images of Mars.

What geological processes have shaped Mars?



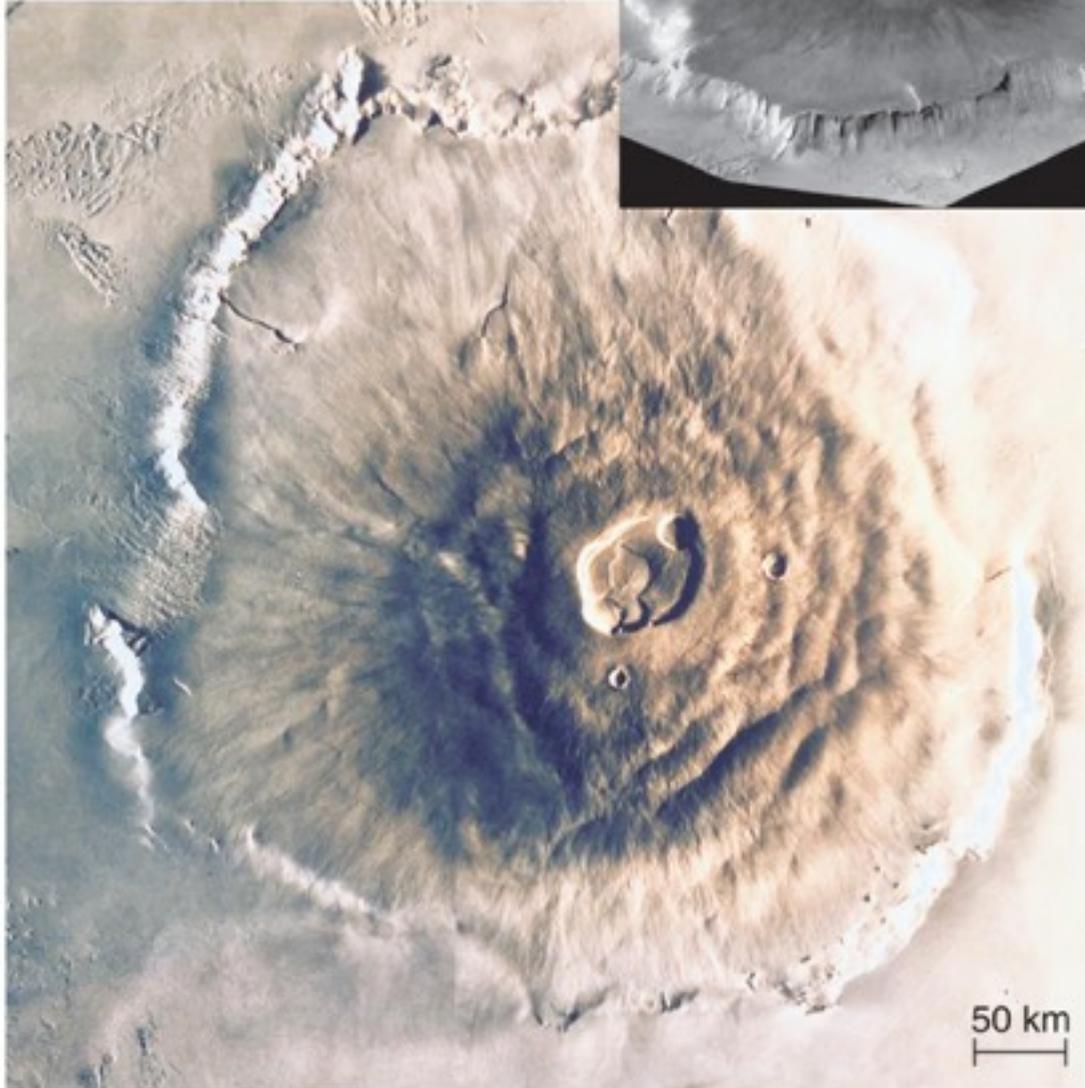
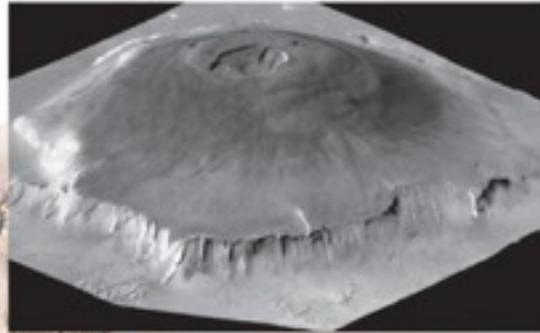
Cratering on Mars



Interactive Figure 

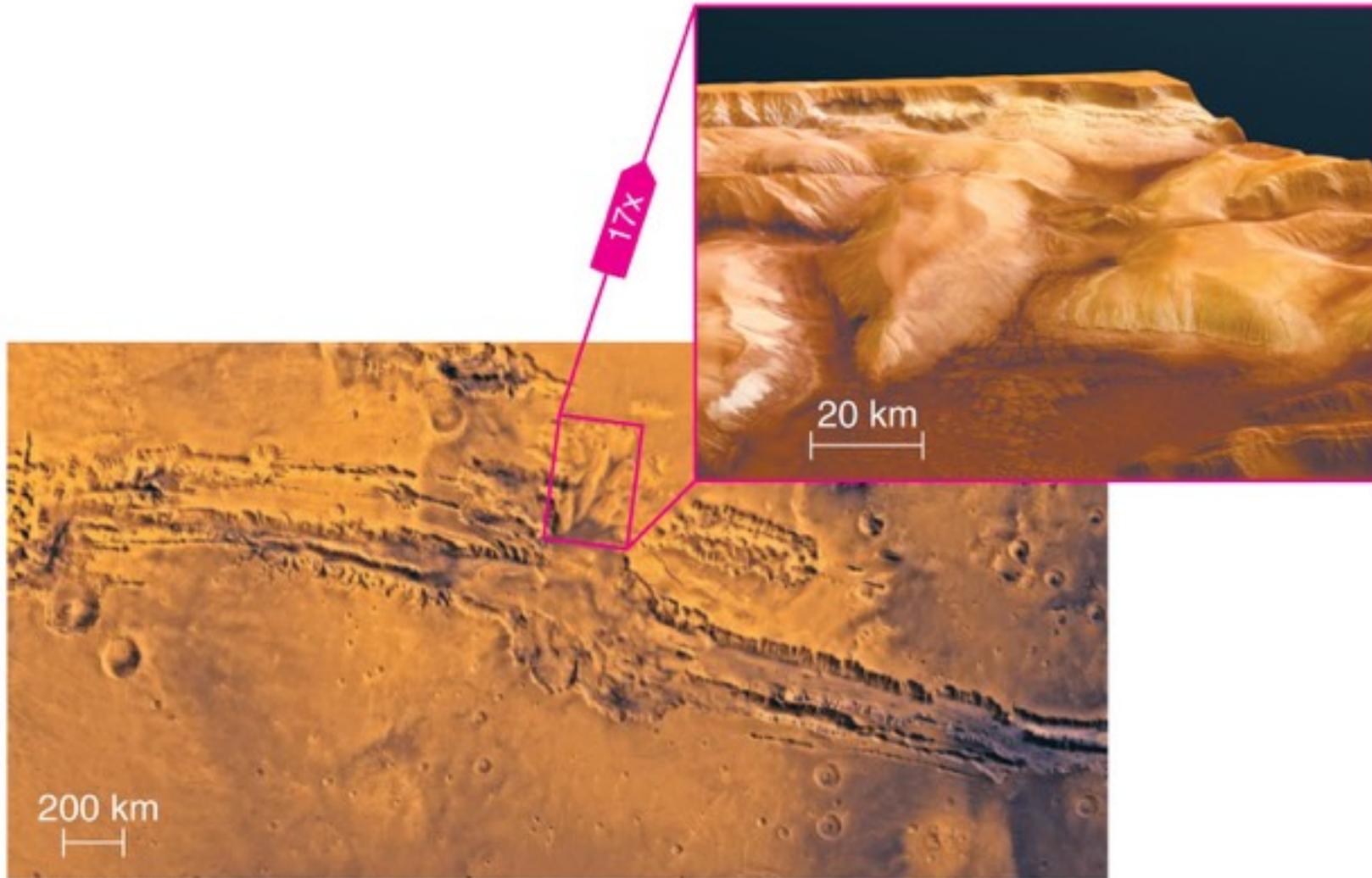
- The amount of cratering differs greatly across Mars's surface.
- Many early craters have been erased.

Volcanism on Mars



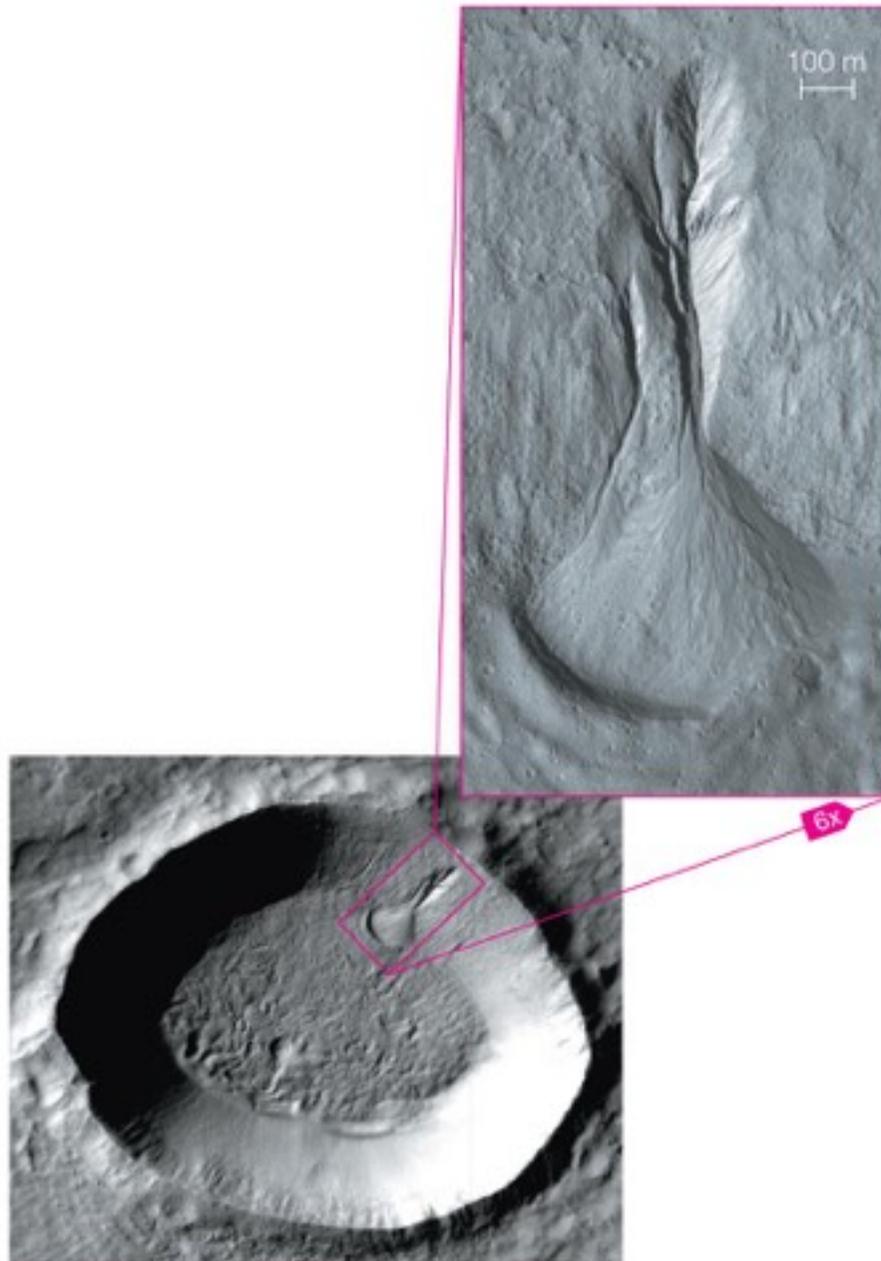
- Mars has many large shield volcanoes.
- Olympus Mons is largest volcano in solar system.

Tectonics on Mars



- The system of valleys known as Valles Marineris is thought to originate from tectonics.

What geological evidence tells us that water once flowed on Mars?



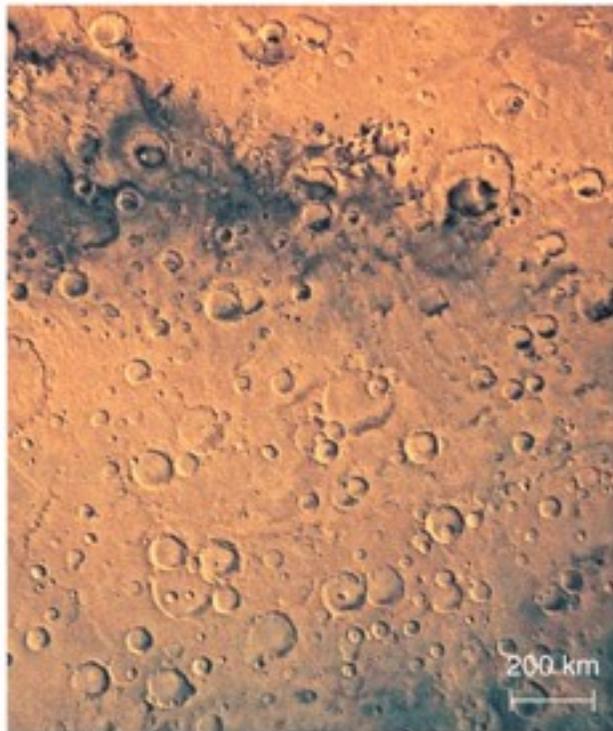
Dry Riverbeds?



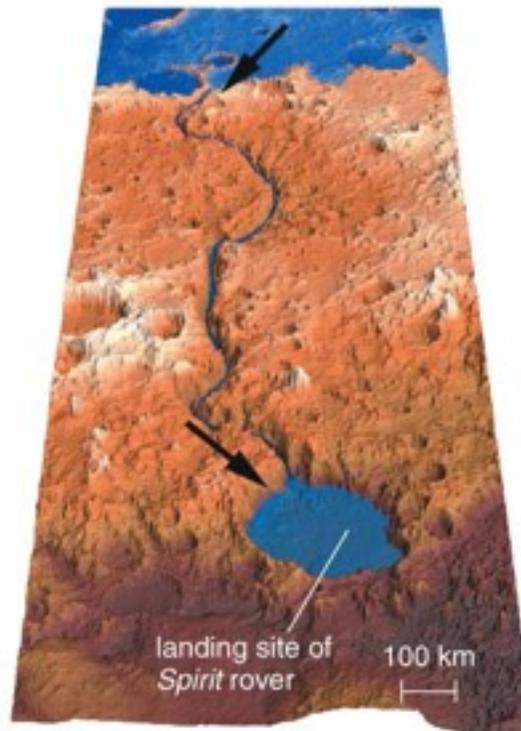
- Close-up photos of Mars show what appear to be dried-up riverbeds.

Erosion of Craters

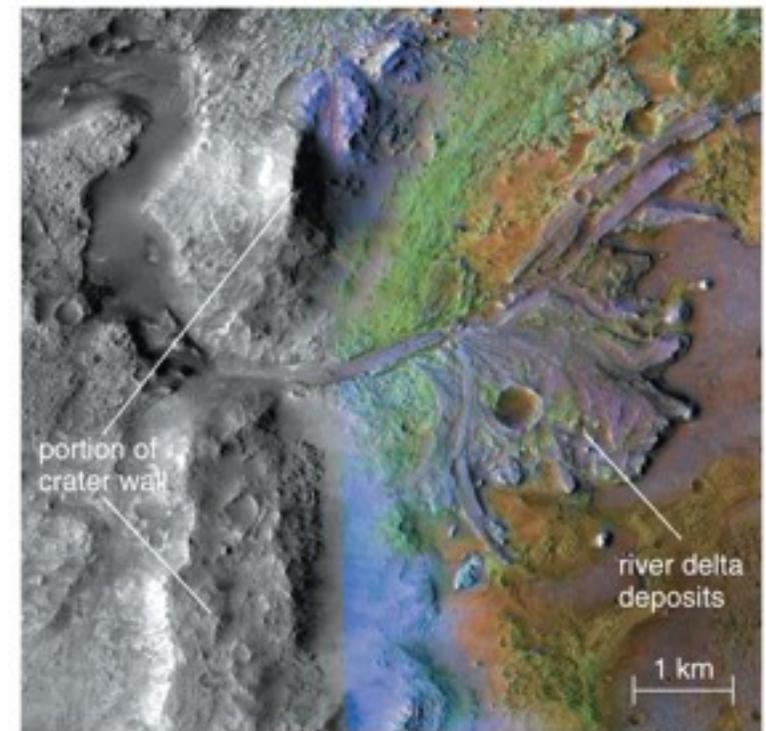
- Details of some craters suggest they were once filled with water.



a This photo shows a broad region of the southern highlands on Mars. The eroded rims of large craters and the relative lack of small craters suggest erosion by rainfall.



b This computer-generated perspective view shows how a Martian valley forms a natural passage between two possible ancient lakes (shaded blue). Vertical relief is exaggerated 14 times to reveal the topography.



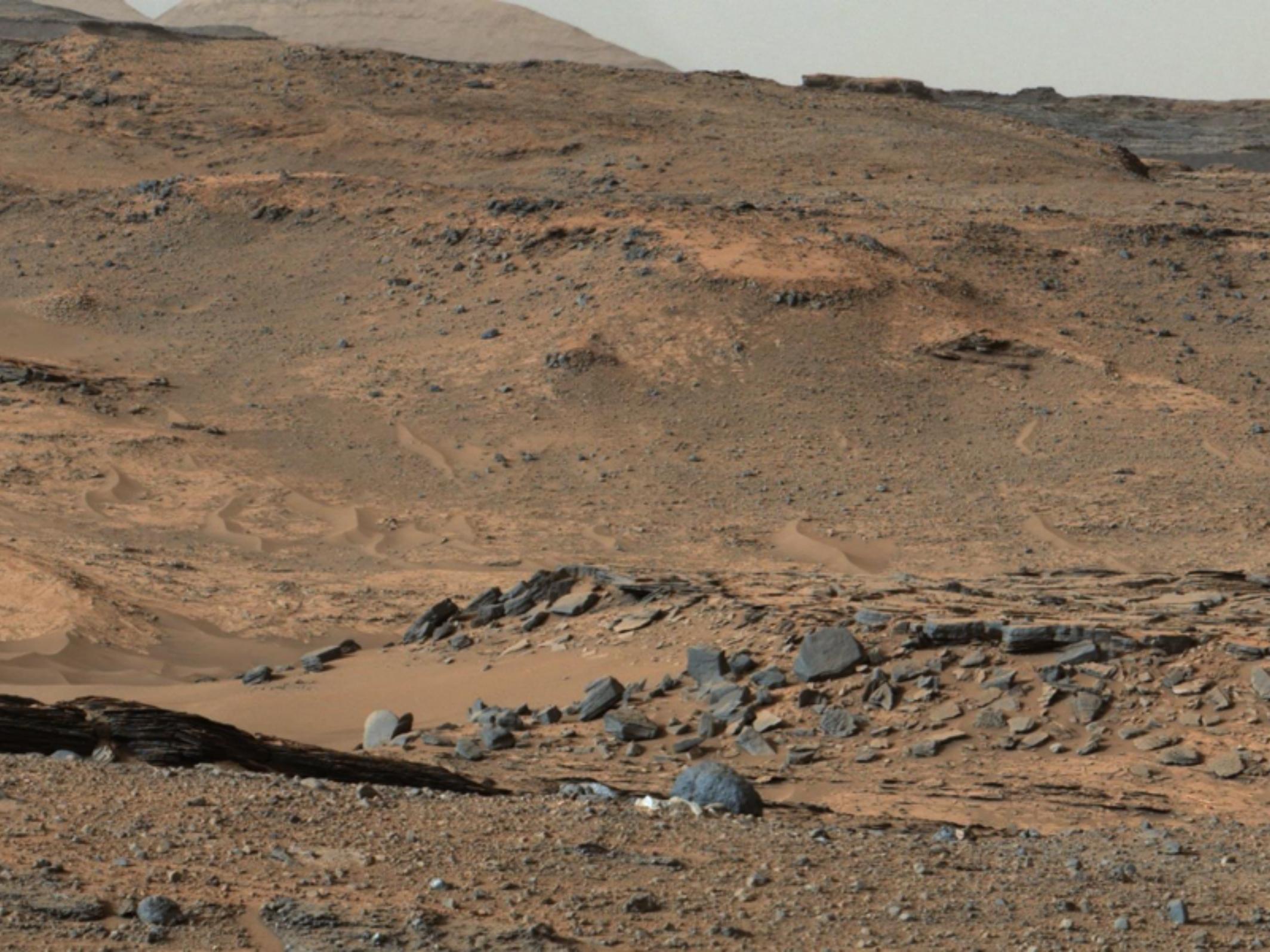
c Combined visible/infrared image of an ancient river delta that formed where water flowing down a valley emptied into a lake filling a large crater (portions of the crater wall are identified). Clay minerals are identified in green.

Spirit & Opportunity (2004) Rovers photoshopped together for scale Curiosity (2012)

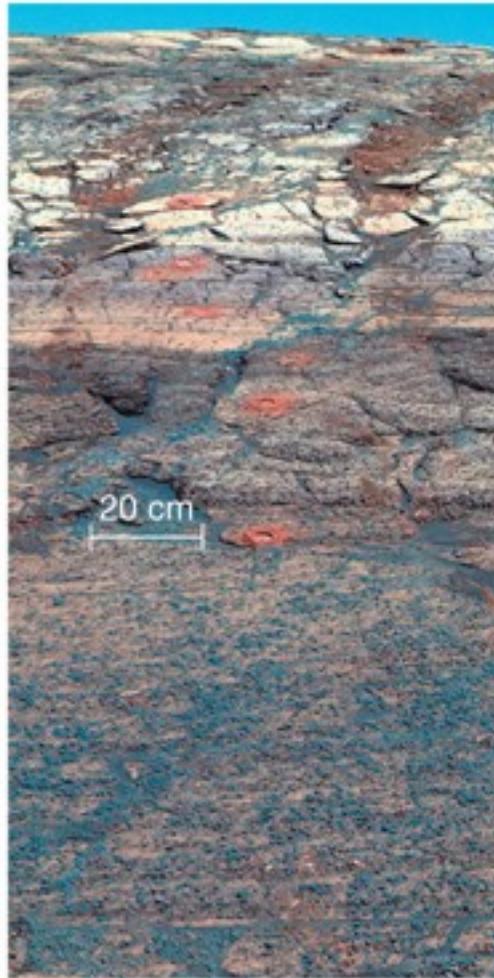


Pathfinder (1997)

Pathfinder landing video



Martian Rocks

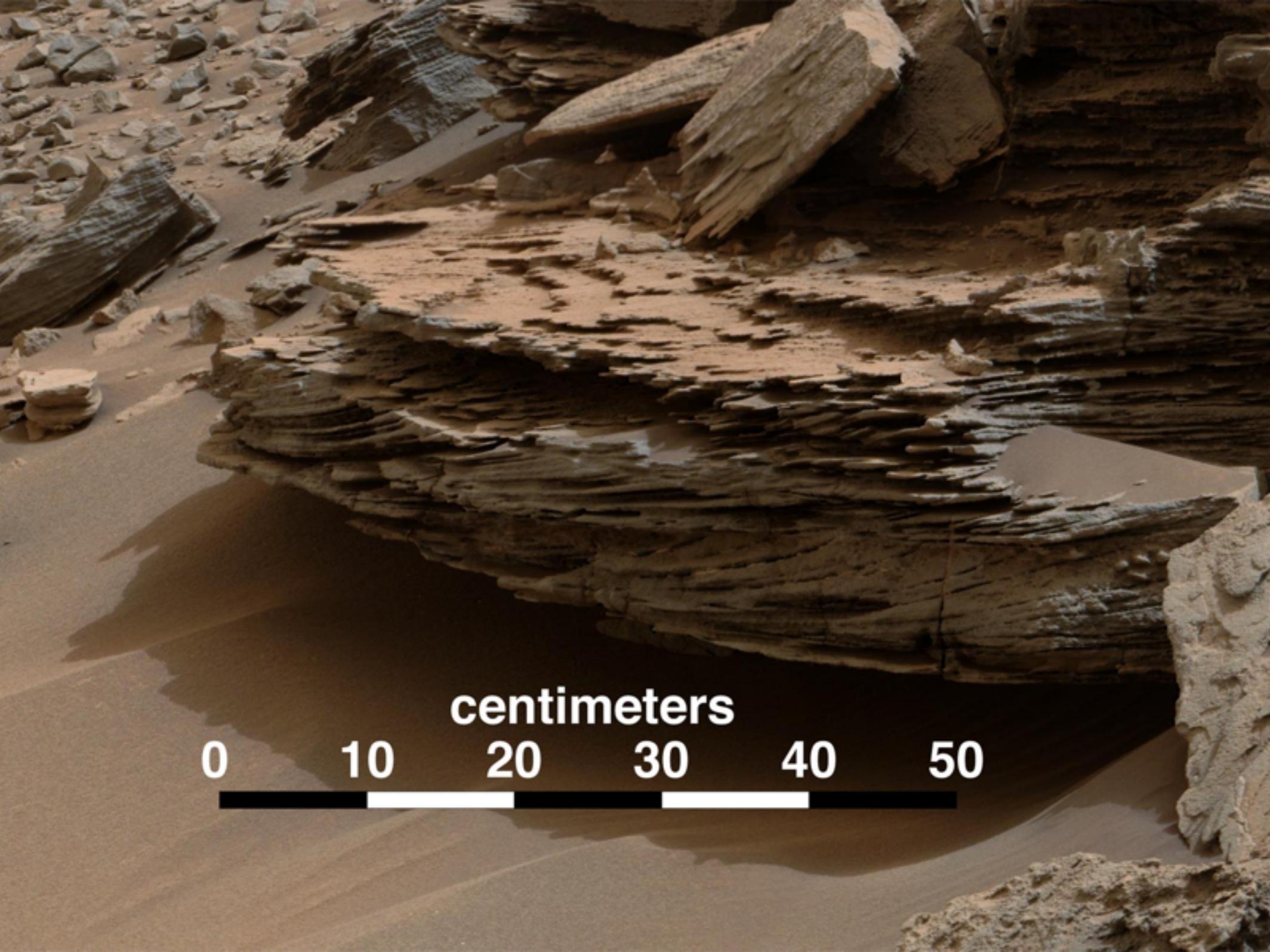


Mars (Endurance Crater)



Earth (Utah)

- Mars rovers have found rocks that appear to have formed in water.



centimeters

0

10

20

30

40

50

Hydrogen Content

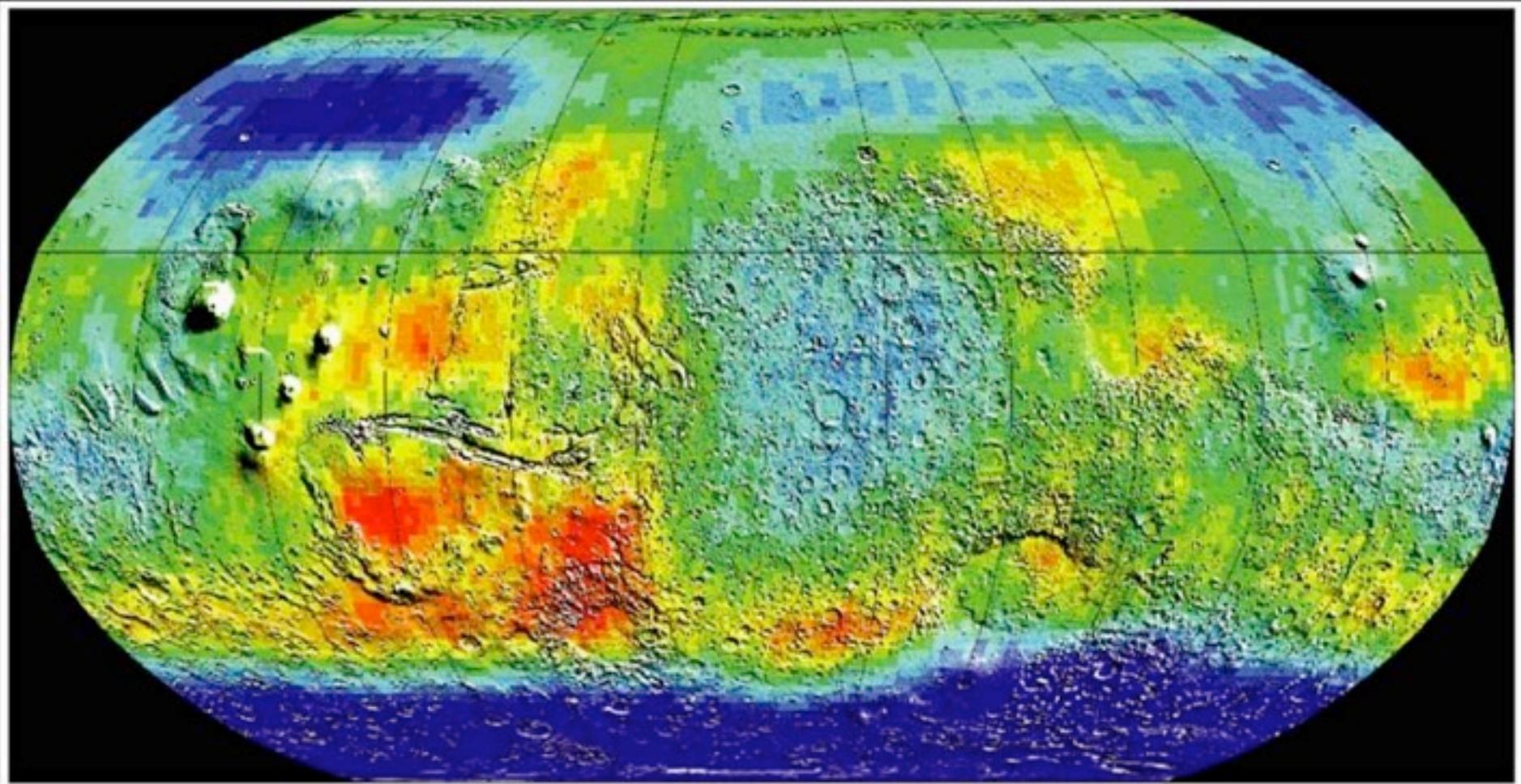
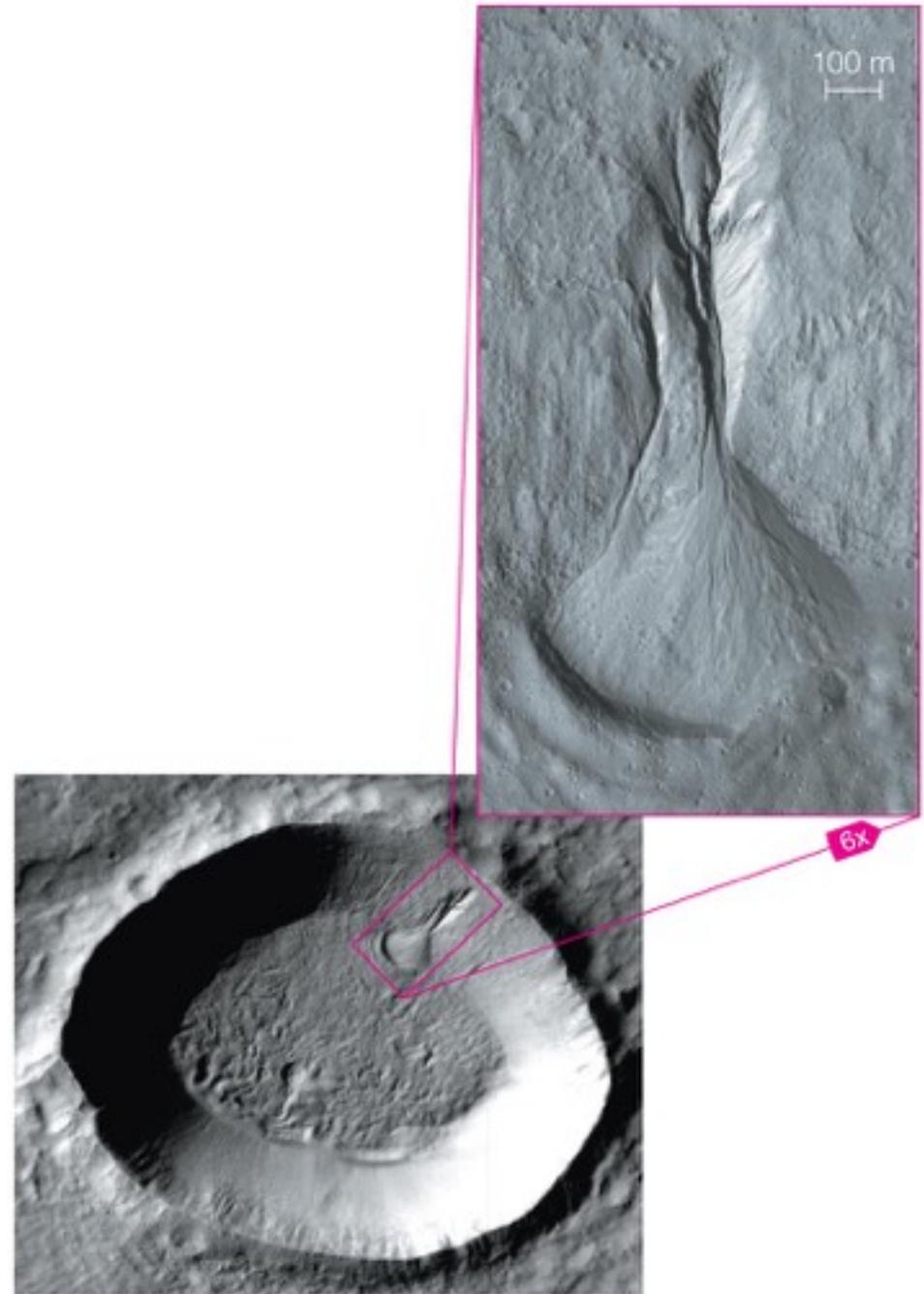


Image Credit: NASA/JPL

- Map of hydrogen content (blue) shows that low-lying areas contain more water ice (permafrost).

Crater Walls

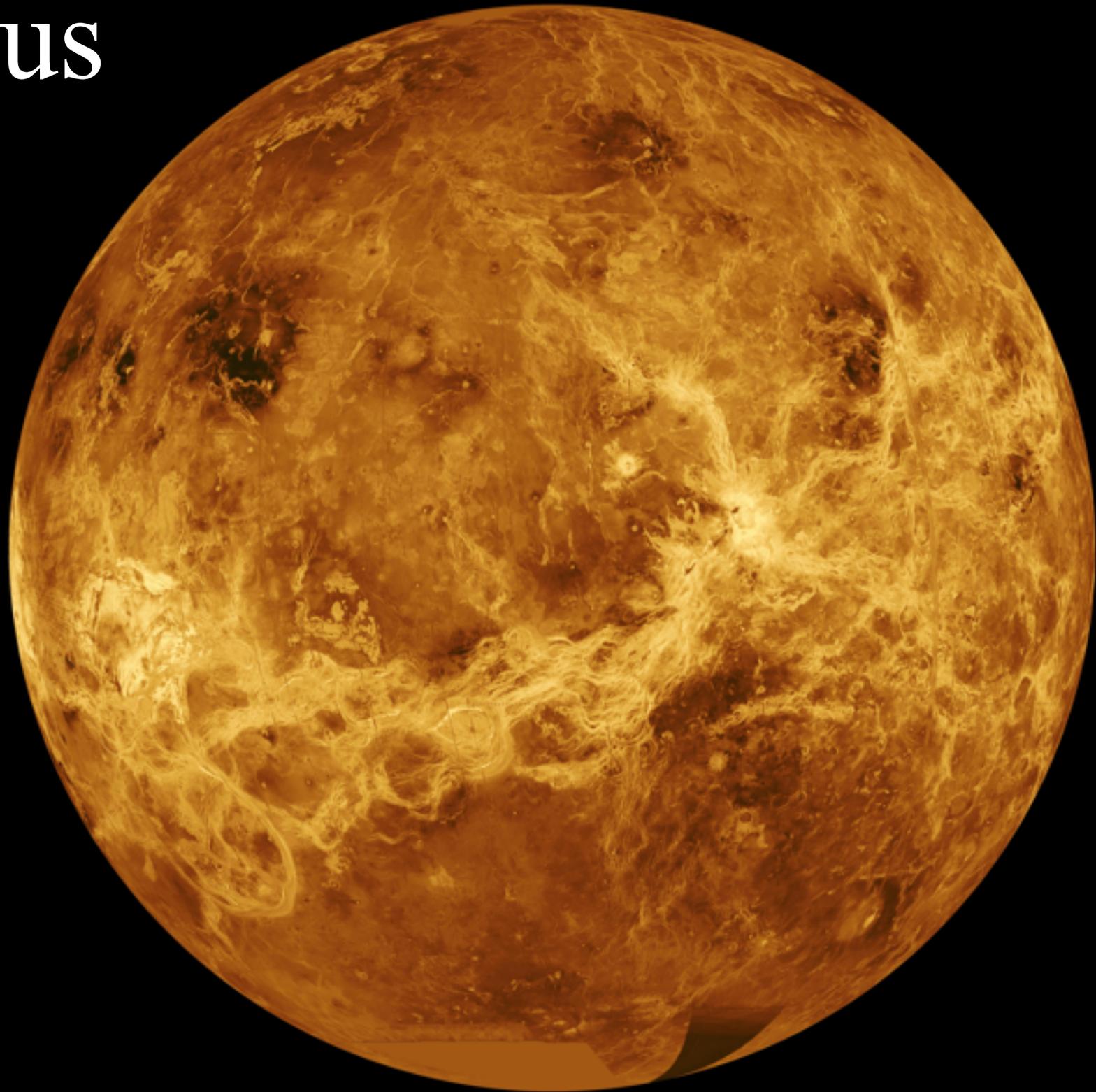
- Gullies on crater walls suggest occasional liquid water flows have happened less than a million years ago.



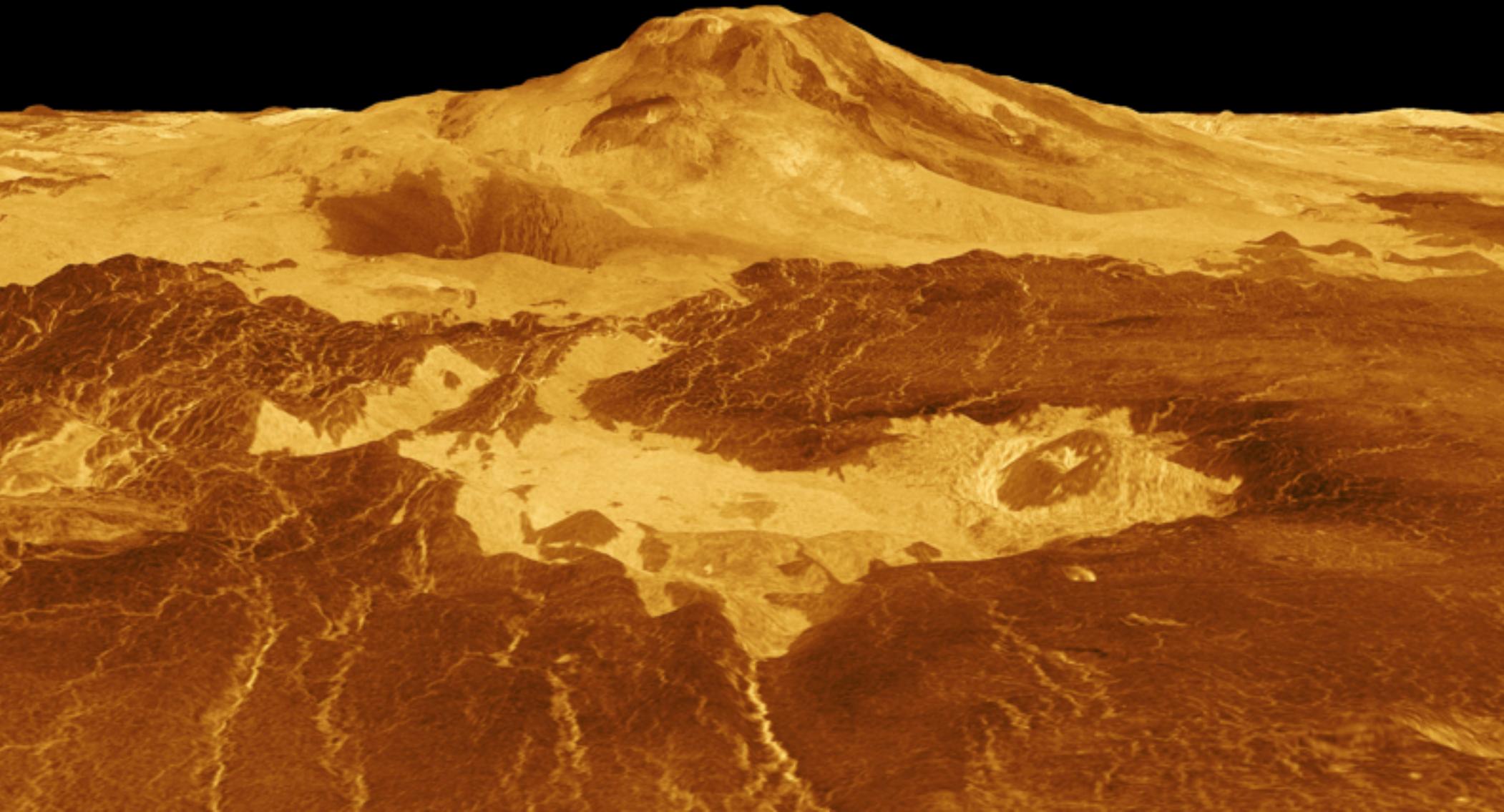
- **Major geological features of Mars**
 - Differences in cratering across surface
 - Giant shield volcanoes
 - Evidence of tectonic activity

- **Evidence that water once flowed on Mars**
 - Some surface features look like dry riverbeds.
 - Some craters appear to be eroded.
 - Rovers have found rocks composed of minerals that form in water.
 - Gullies in crater walls may indicate recent water flows.

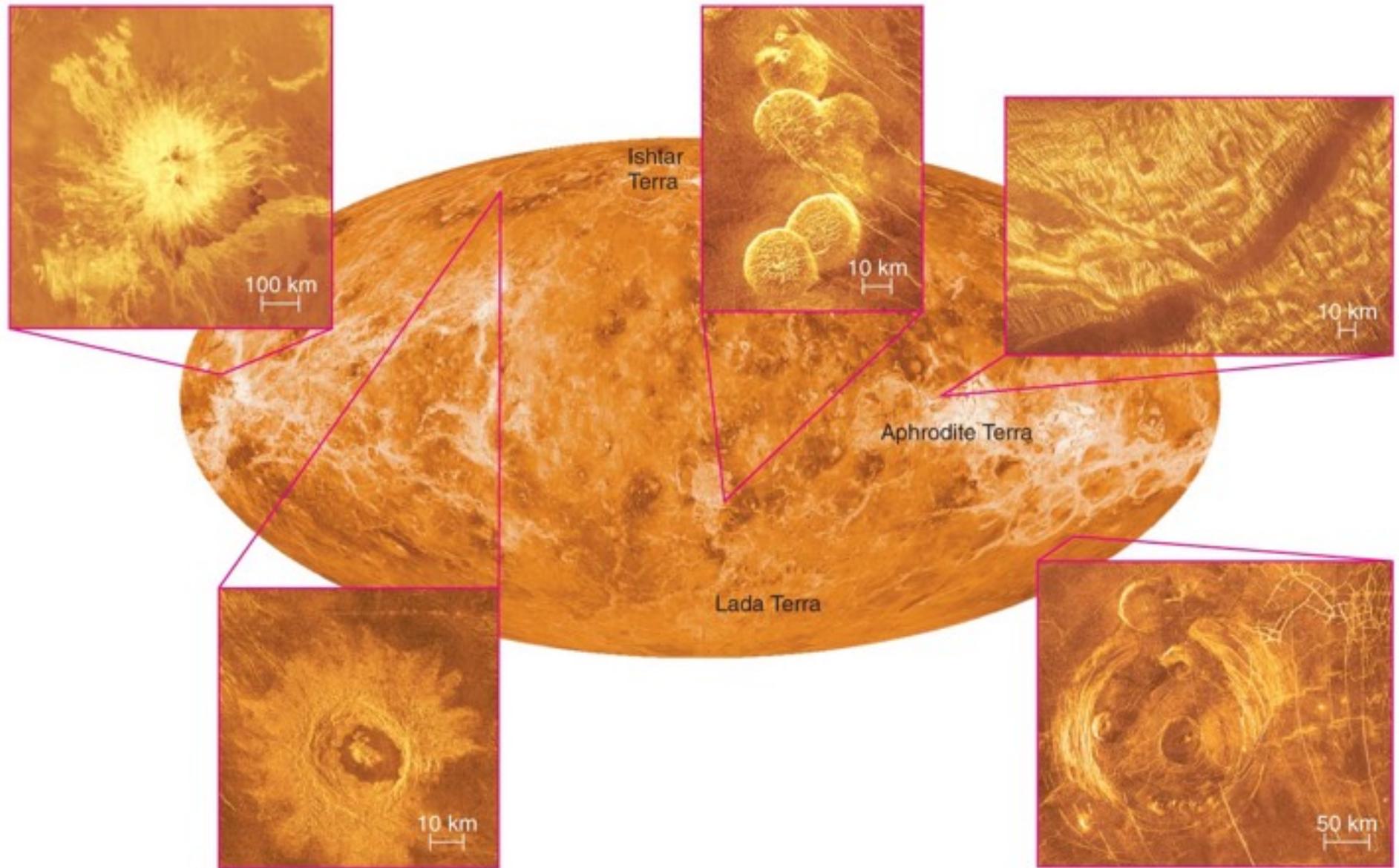
Venus



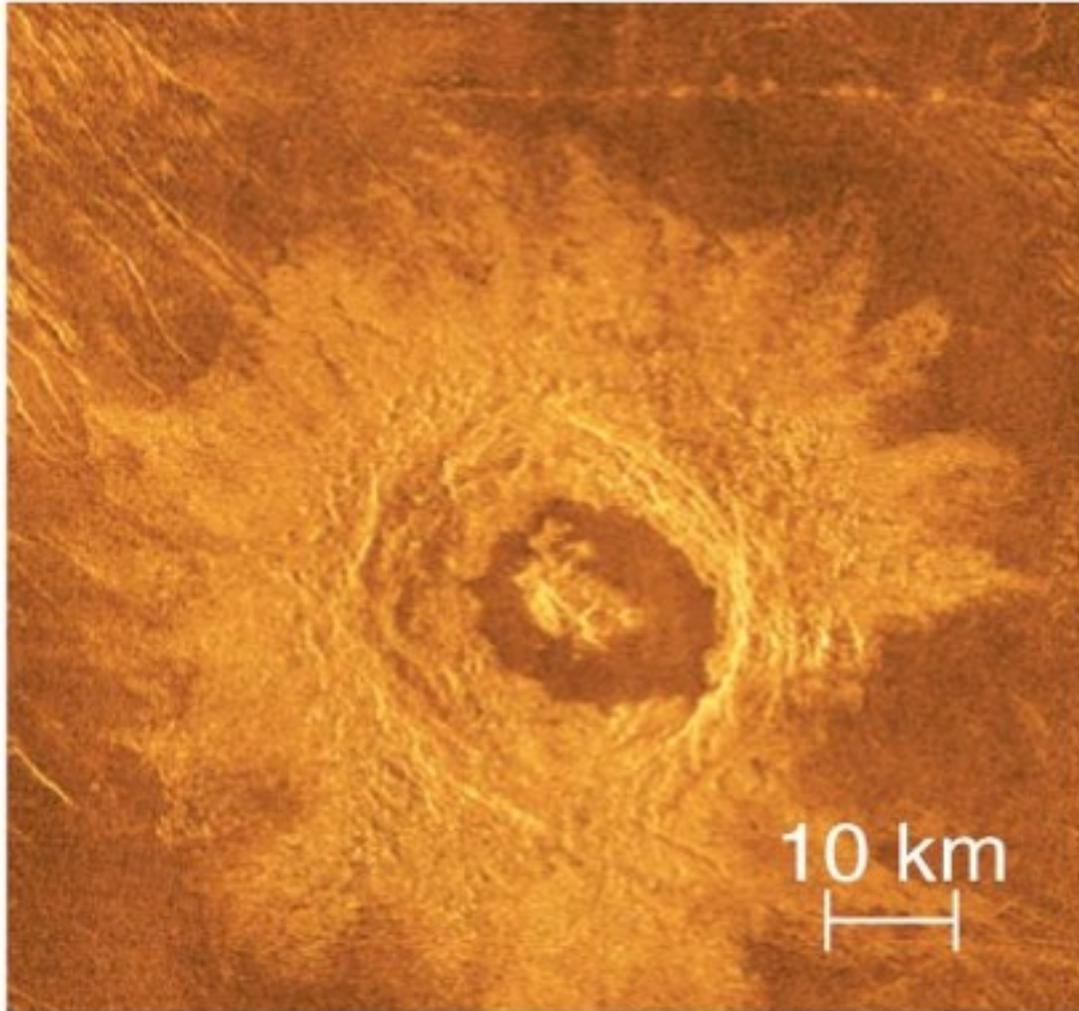
- Surface mapped by radar to penetrate thick clouds
- Magellan orbiter (1990 - 1994)
 - burned up in atmosphere



What geological processes have shaped Venus?

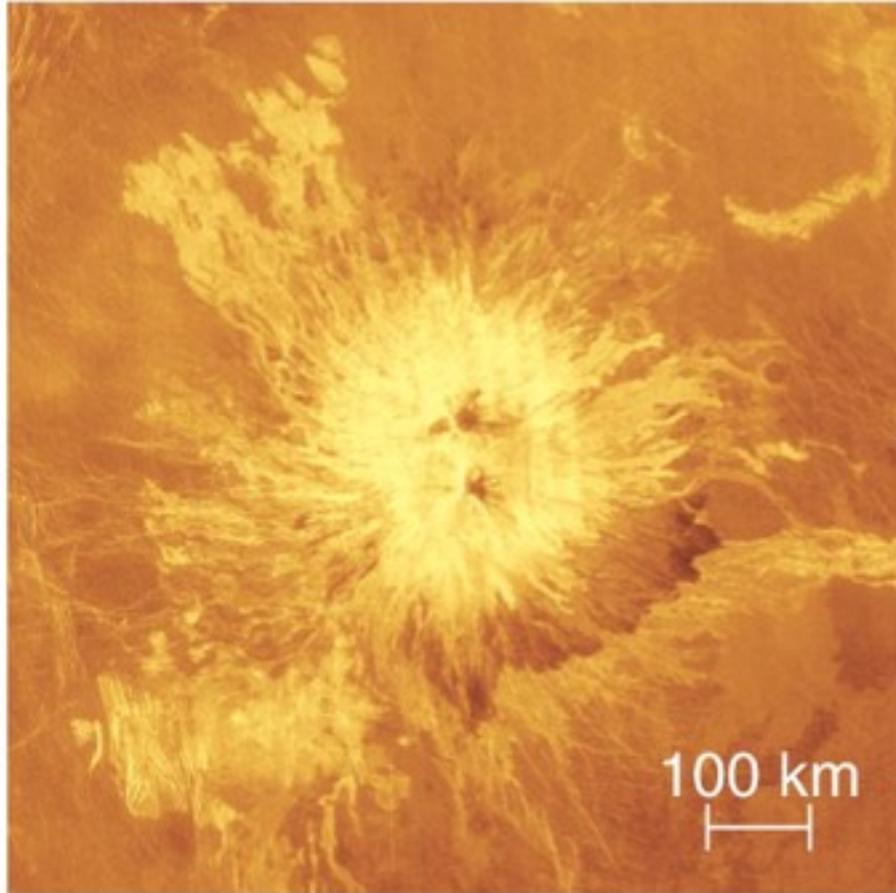


Cratering on Venus

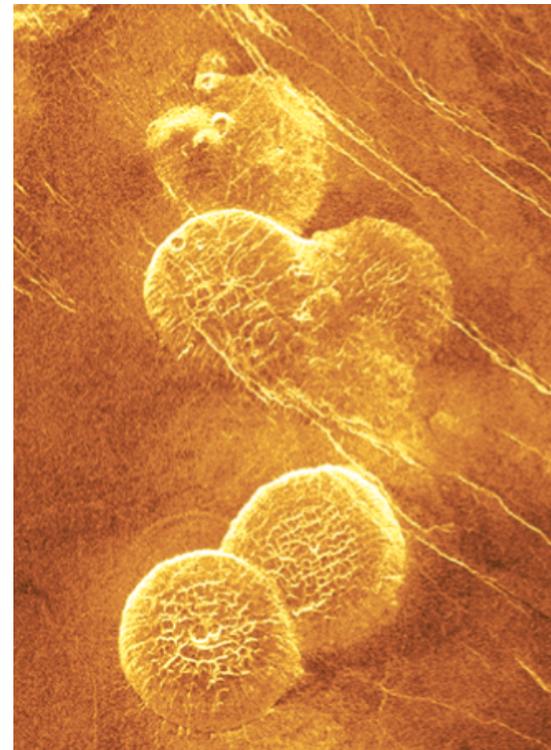


- Venus has impact craters, but fewer than the Moon, Mercury, or Mars.
- Mostly large craters
 - shielded from small impactors by thick atmosphere

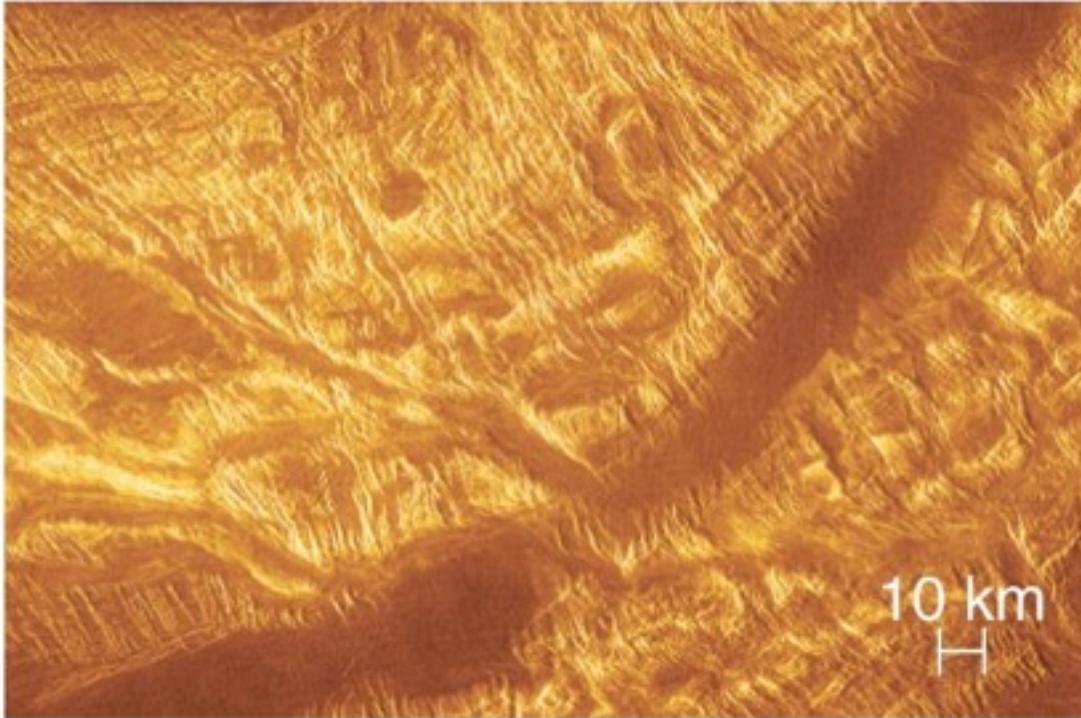
Volcanoes on Venus



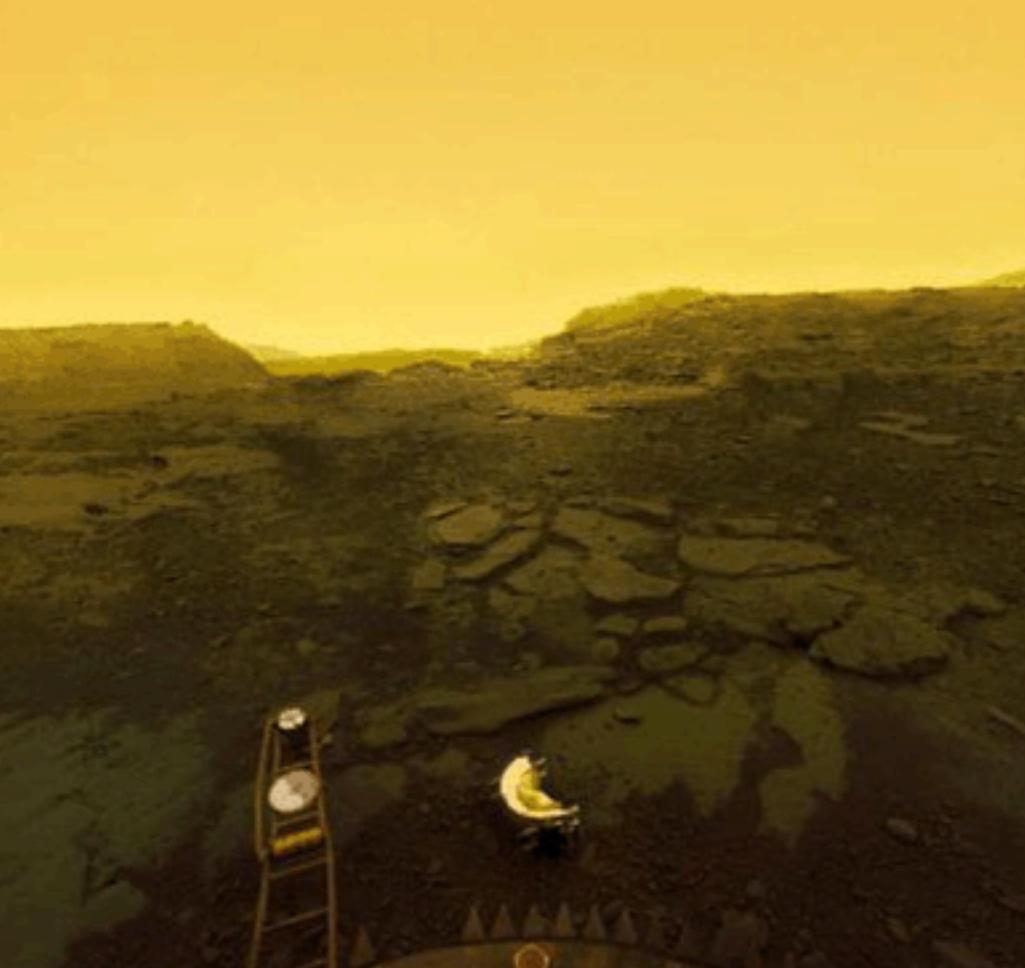
- It has many volcanoes, including both shield volcanoes and stratovolcanoes.



Tectonics on Venus



- The planet's fractured and contorted surface indicates tectonic stresses.



Color as seen on the surface of Venus



Color with atmospheric effects removed

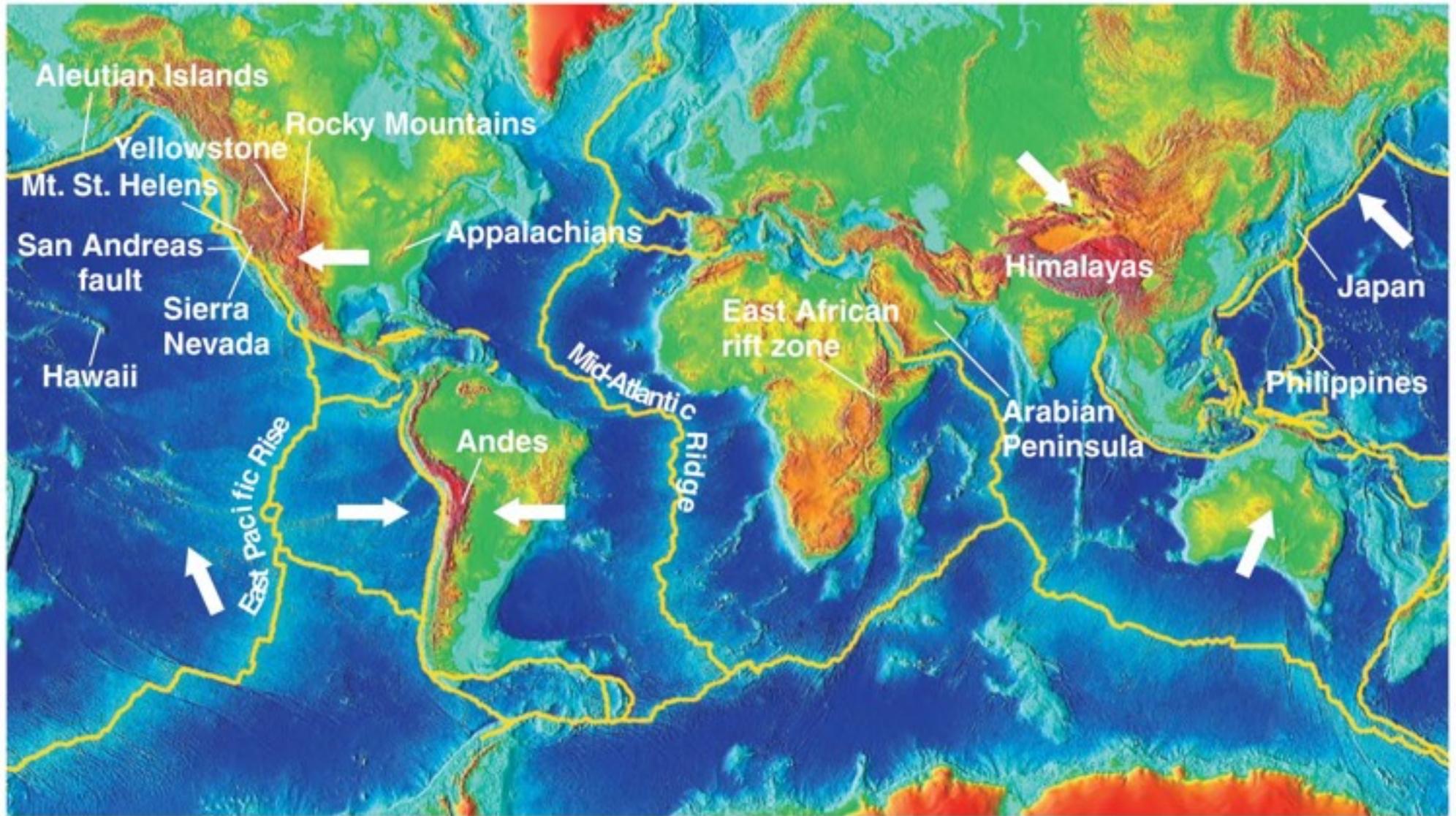


- Photos of rocks taken by landers show little erosion.
- No flowing water
- The Russian lander only lasted a few minutes

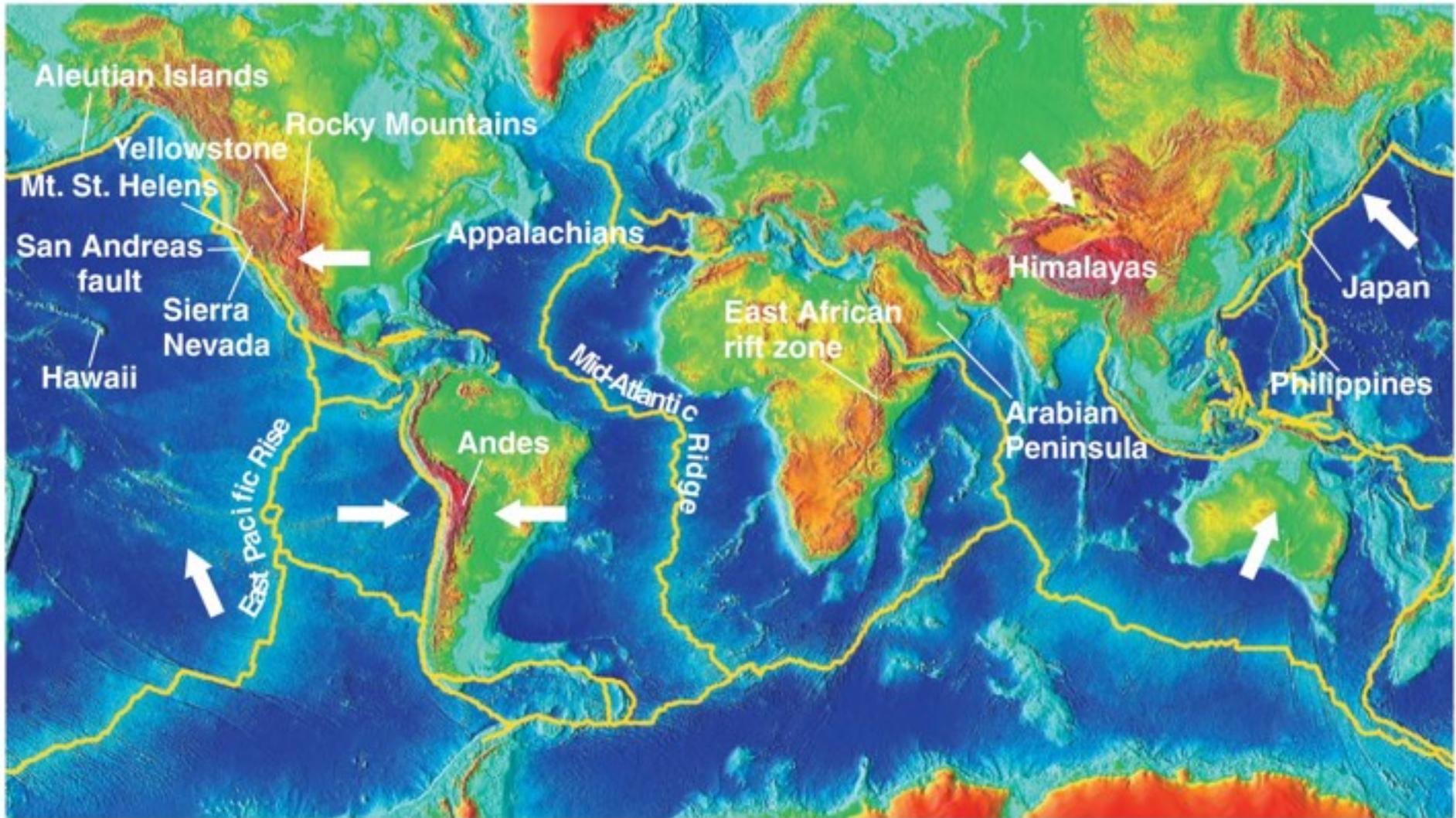
Does Venus have plate tectonics?

- Venus does not appear to have plate tectonics, but entire surface seems to have been "repaved" 750 million years ago.
 - Weaker convection?
 - Thicker or more rigid lithosphere?
 - Some role for water in greasing plate tectonics on Earth?

How is Earth's surface shaped by plate tectonics?



Continental Motion

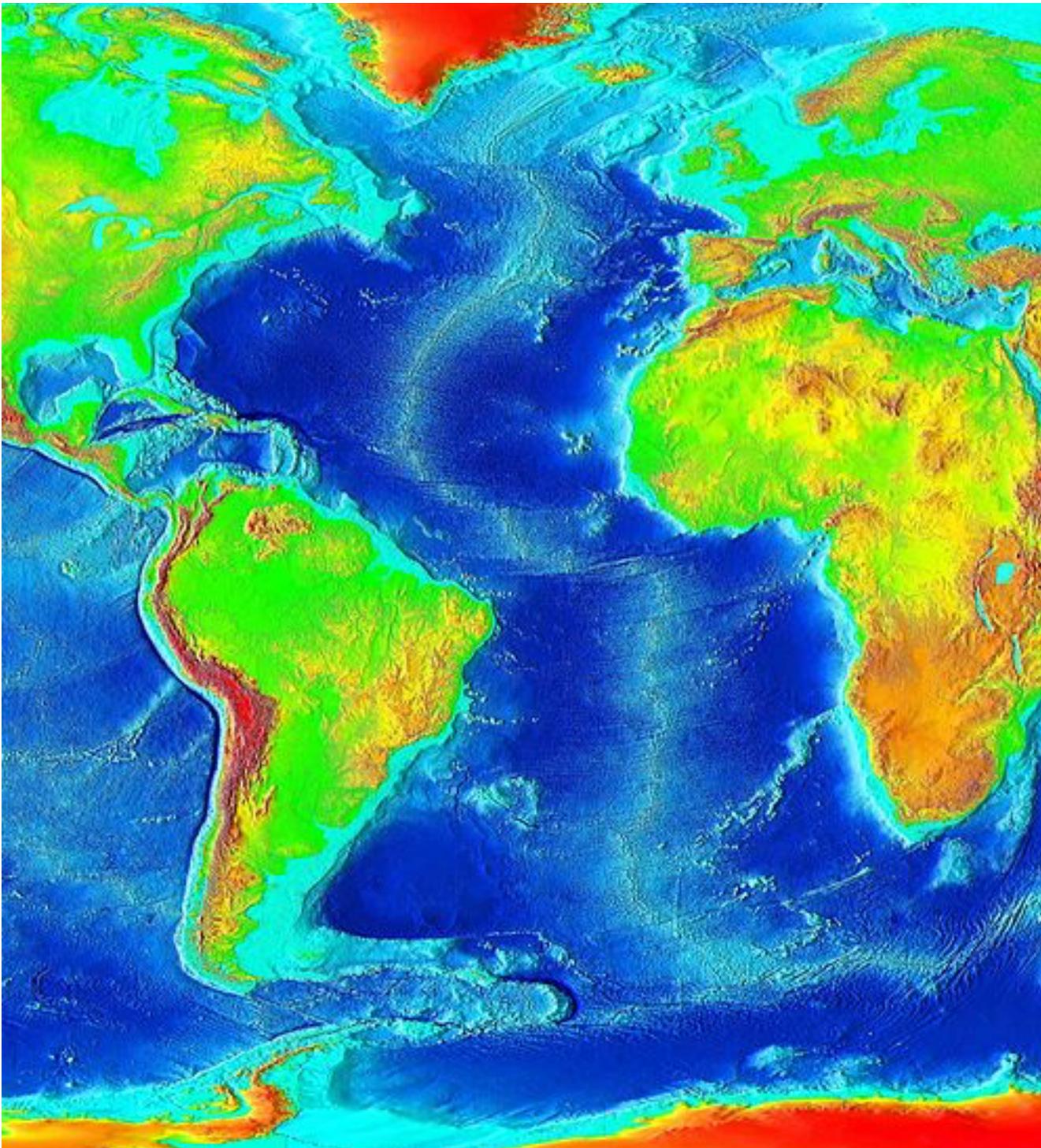


- Motion of the continents can be measured with GPS.

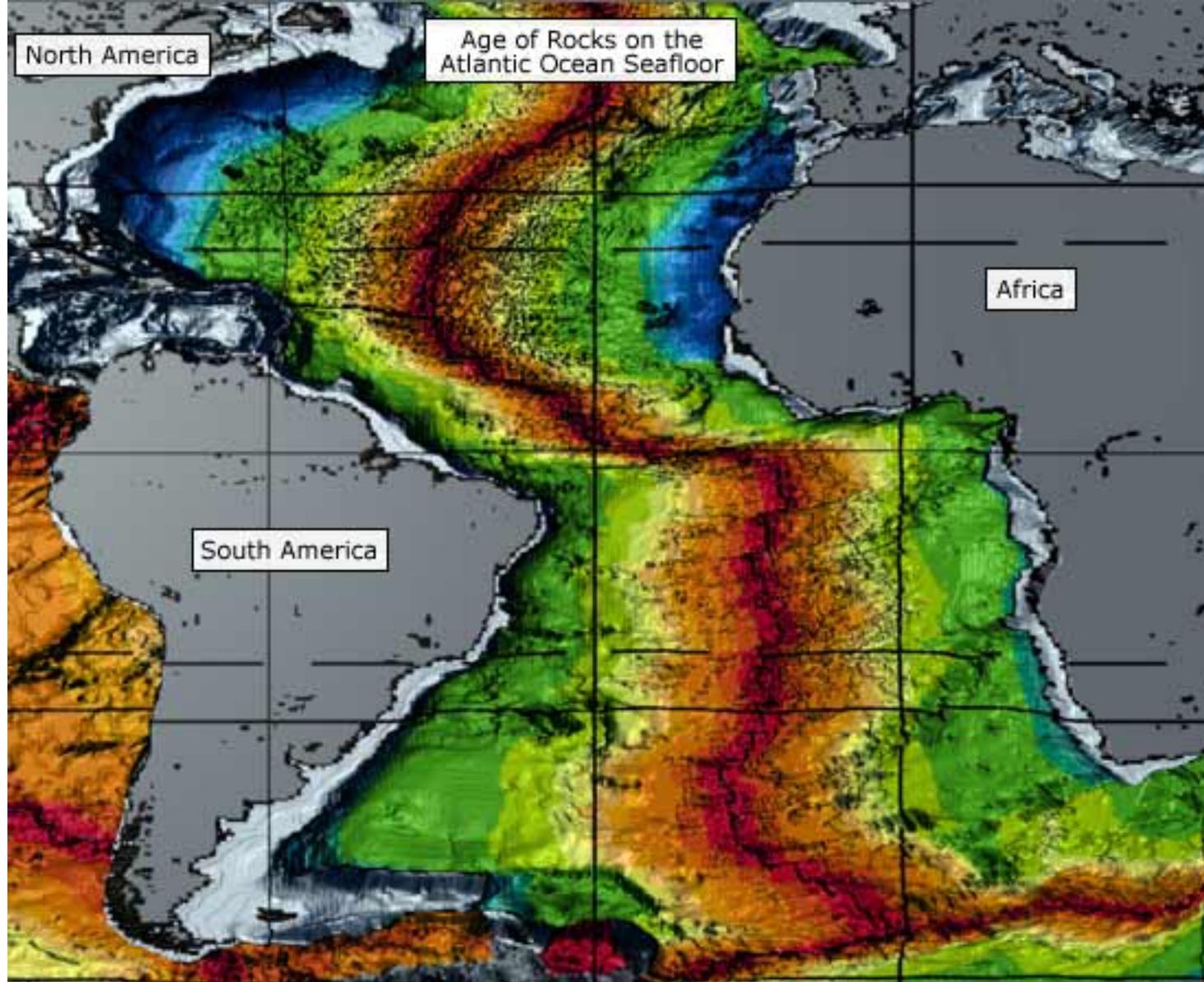
Continental Motion



- The idea of continental drift was inspired by the puzzle-like fit of the continents.
- Mantle material erupts where the seafloor spreads.



- Mid-Atlantic ridge
- Chain of mountains from whence seafloor spreads
- Age gradient in rocks with youngest at the center of spreading

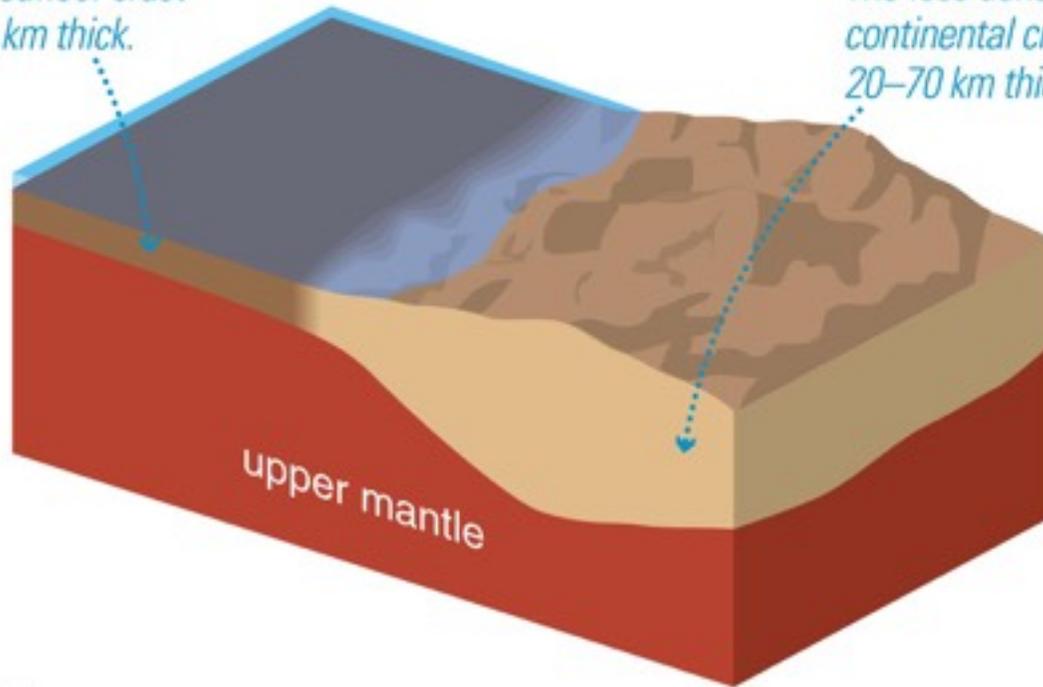


Younger rocks colored red

Seafloor Crust

The relatively dense, young seafloor crust is 5–10 km thick.

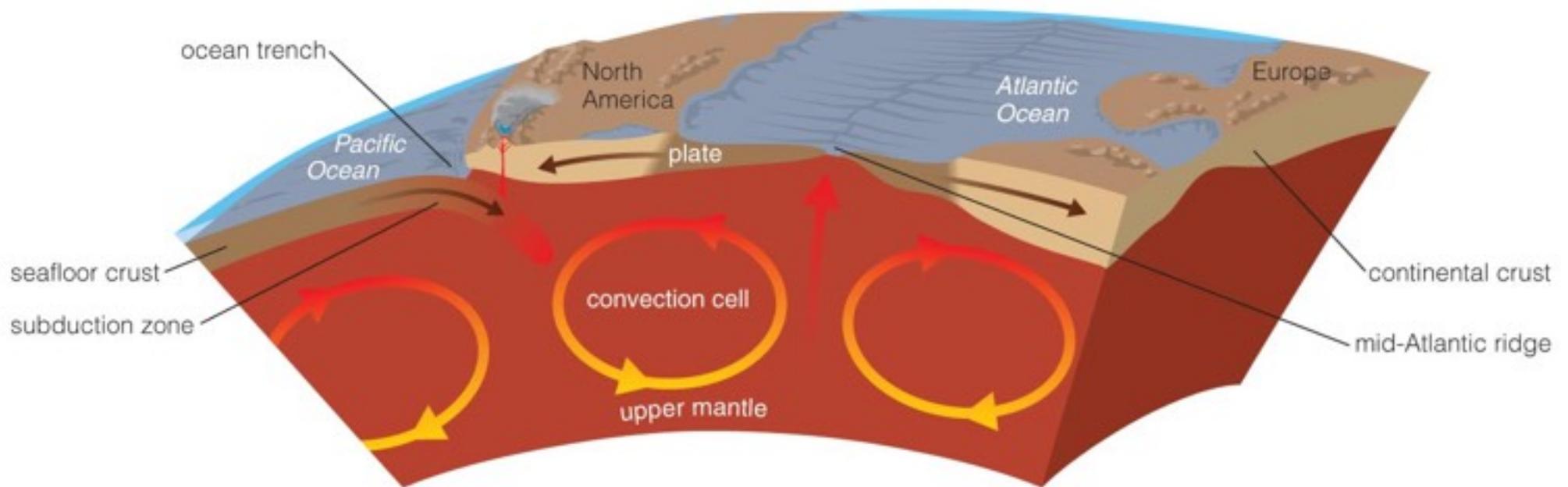
The less dense, older continental crust is 20–70 km thick.



- Thin seafloor crust differs from thick continental crust.
- Dating of the seafloor shows that it is usually quite young.

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Seafloor Recycling



- Seafloor is recycled through a process known as subduction.

Surface Features



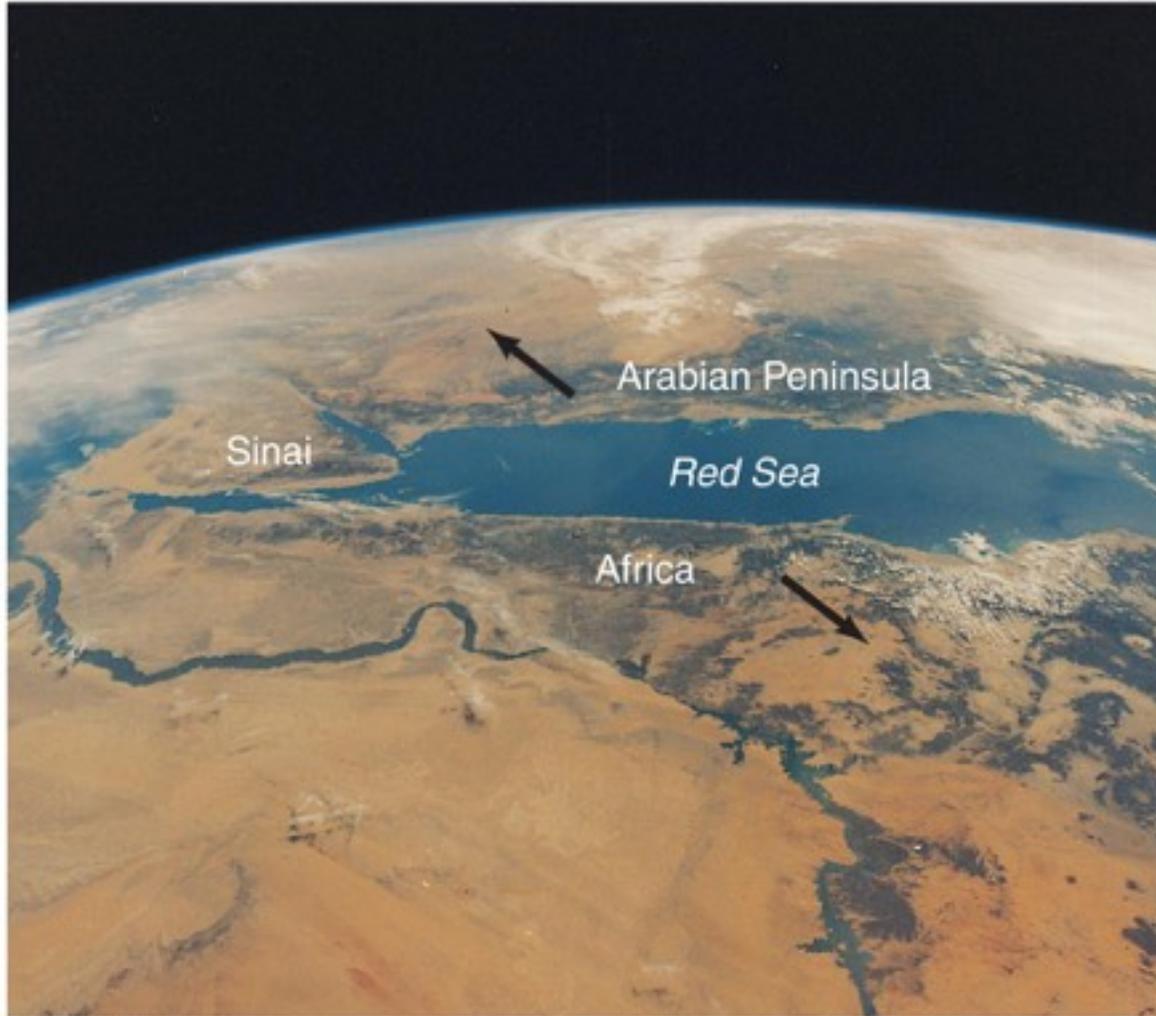
- Major geological features of North America record the history of plate tectonics.

Surface Features



- The Himalayas formed from a collision between plates.

Surface Features



- The Red Sea is formed where plates are pulling apart.

Rifts, Faults, Earthquakes



- The San Andreas fault in California is a plate boundary.
- Motion of plates can cause earthquakes.

Ring of Fire

- Boundaries of plates traced by Earthquakes and Volcanos

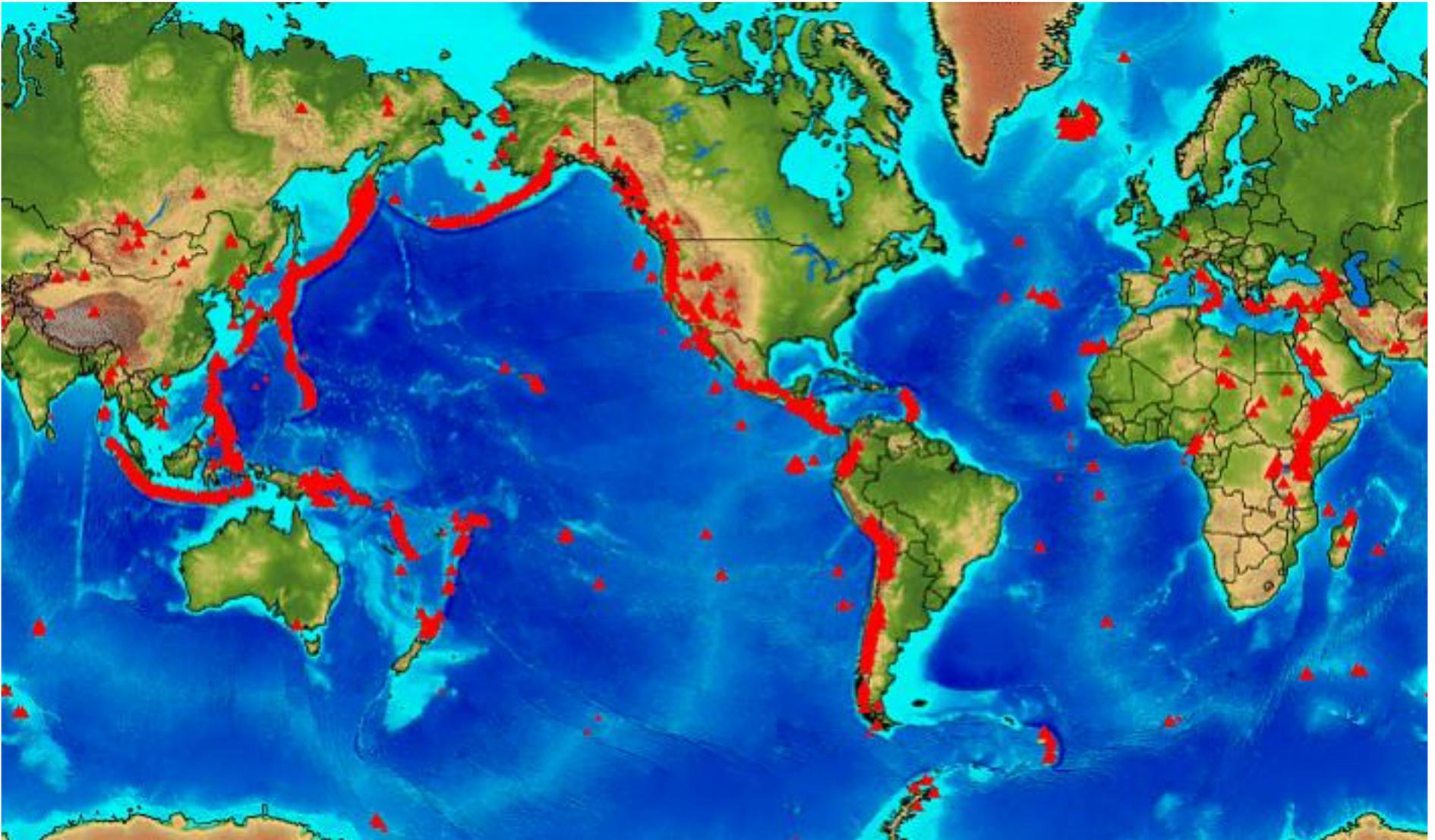
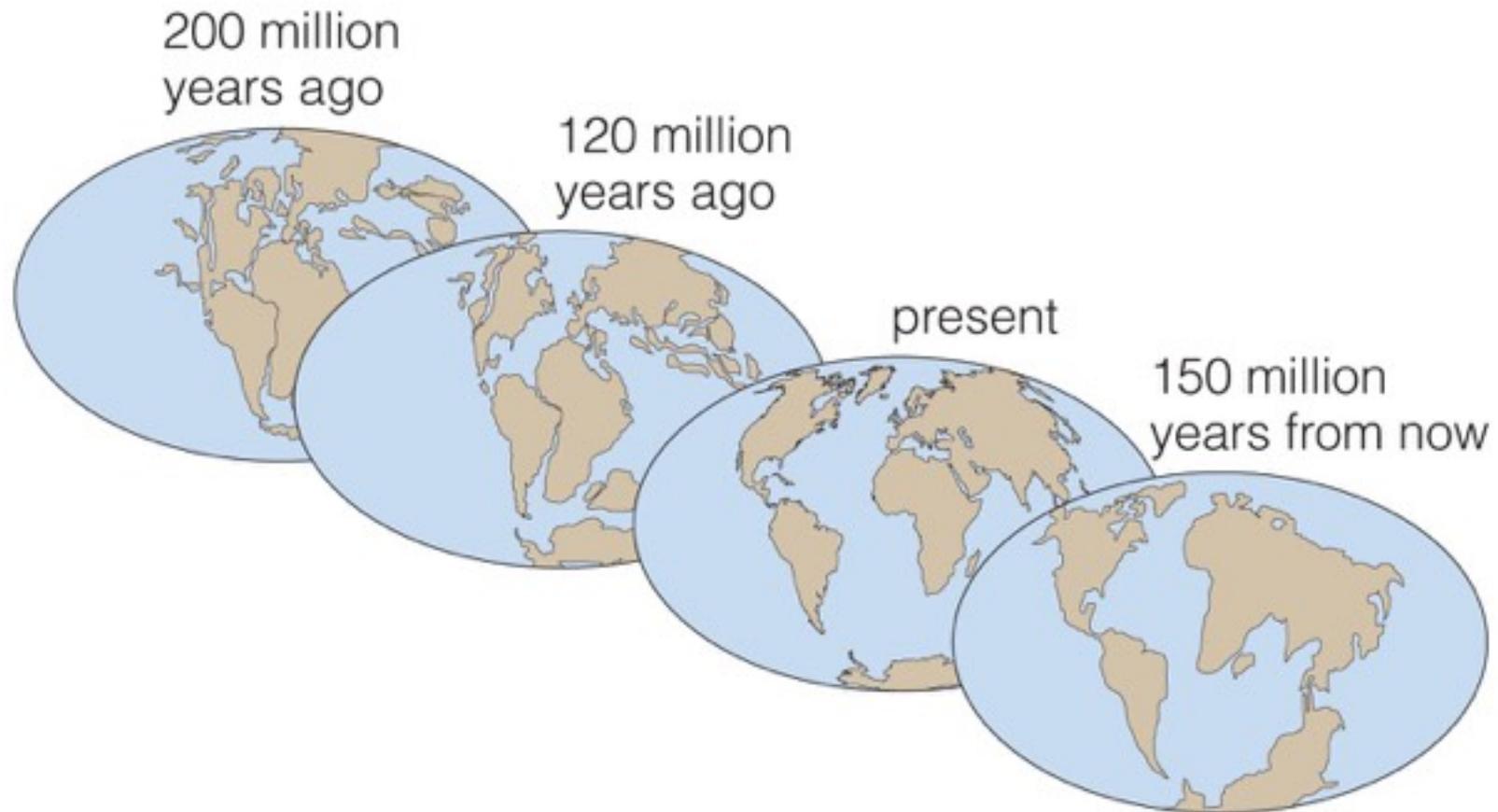


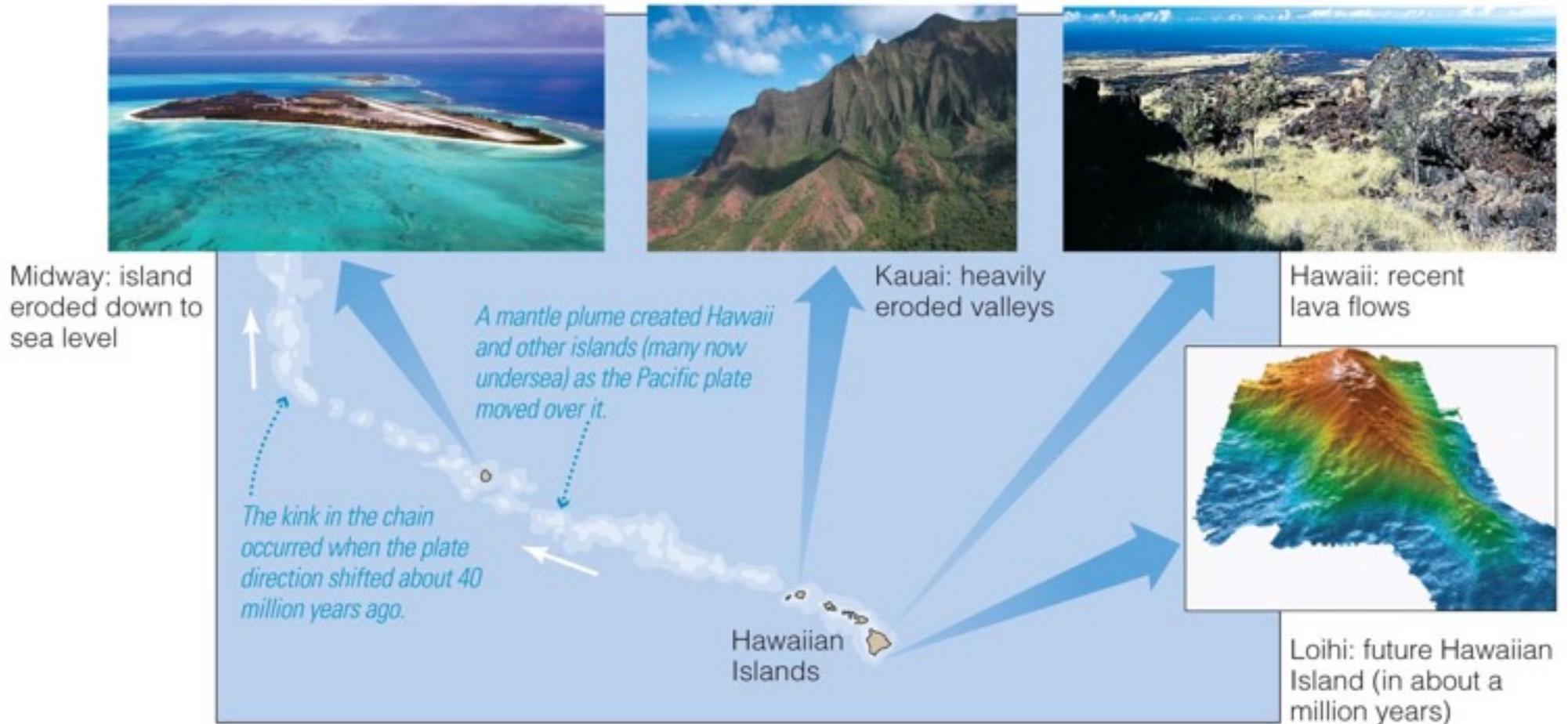
Plate Motions

- Measurements of plate motions tell us past and future layout of the continents.



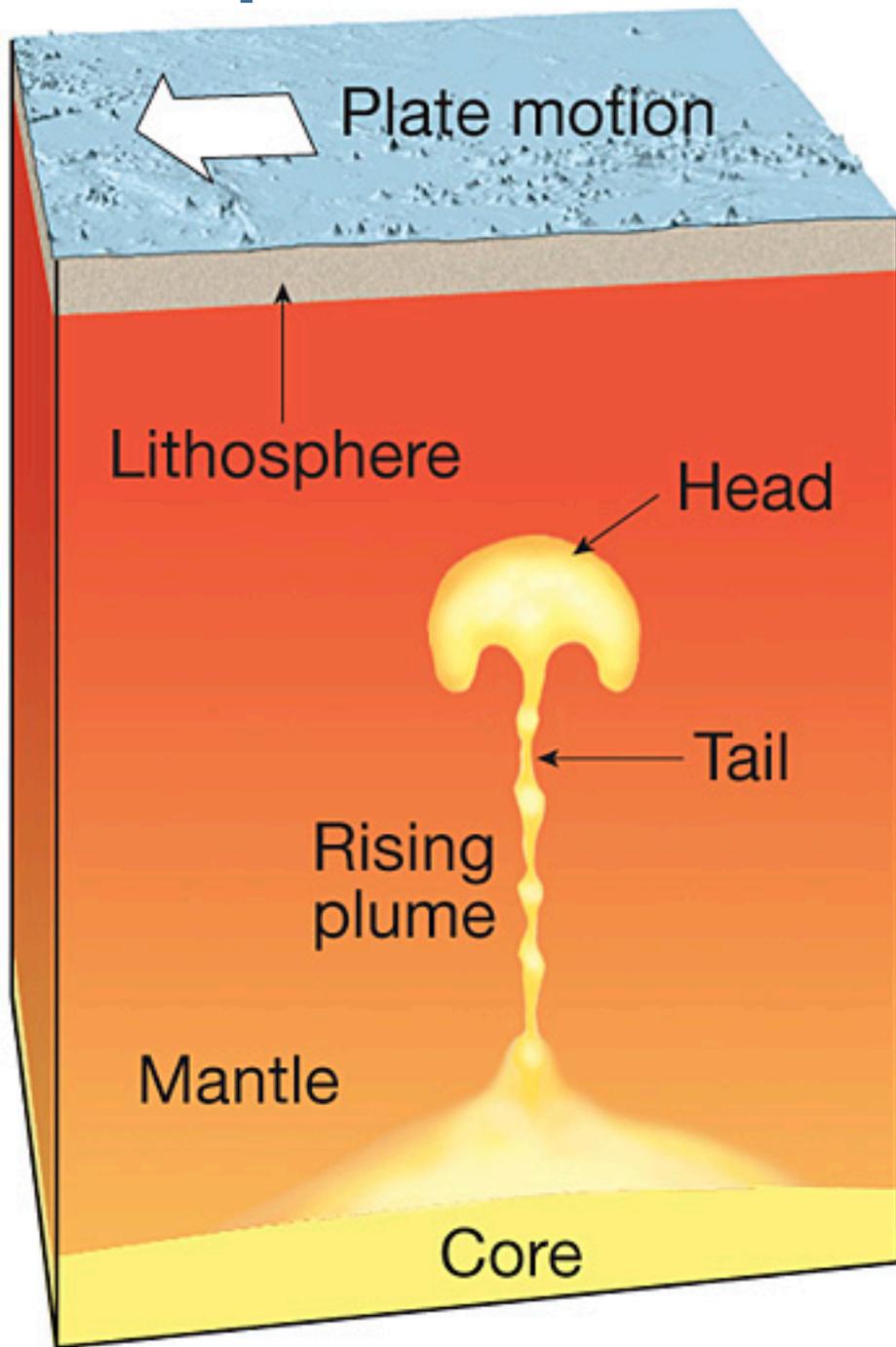
<https://www.youtube.com/watch?v=cQVoSyVu9rk>

Hot Spots

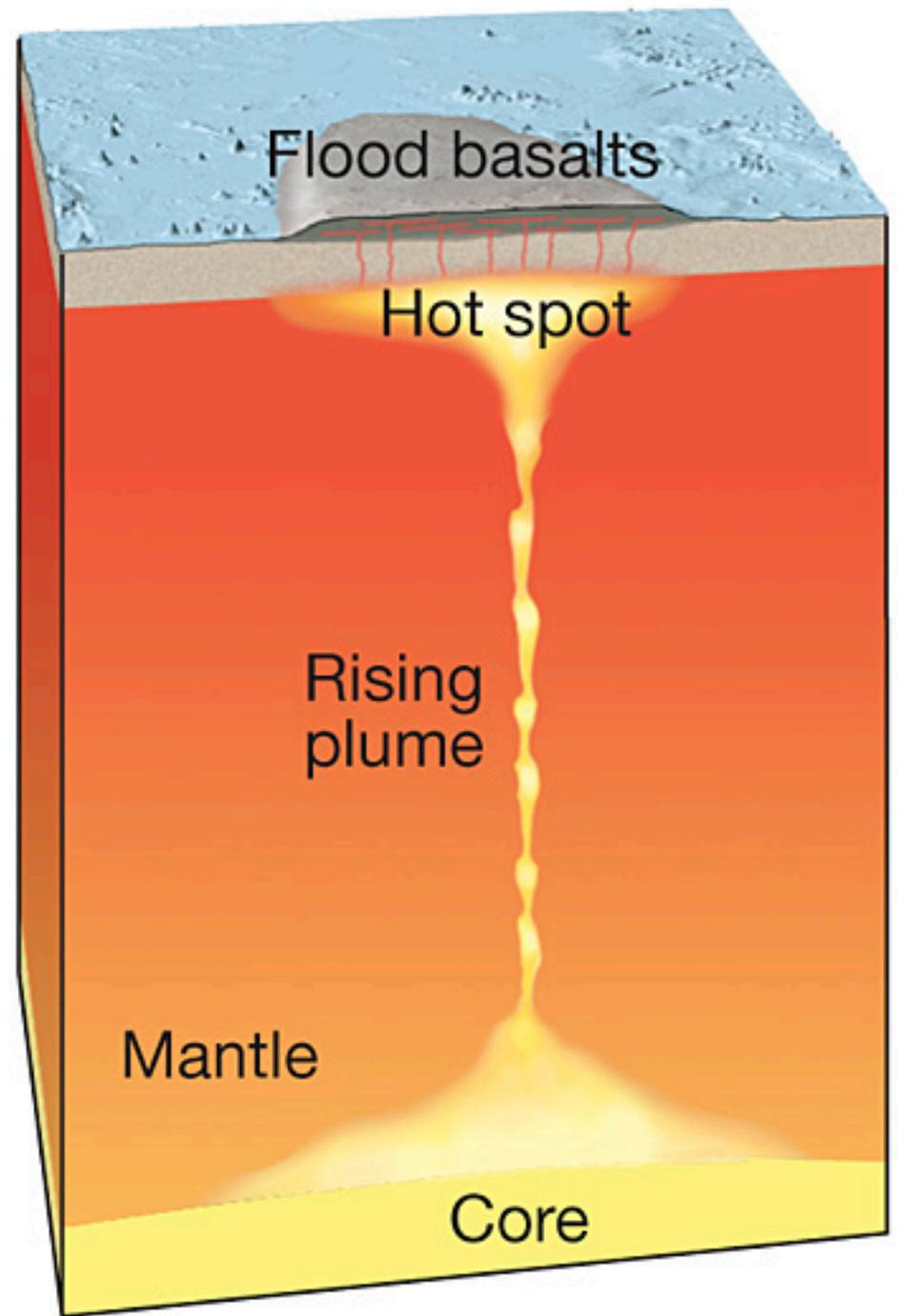


- The Hawaiian islands have formed where a plate is moving over a volcanic hot spot.

Hot Spots



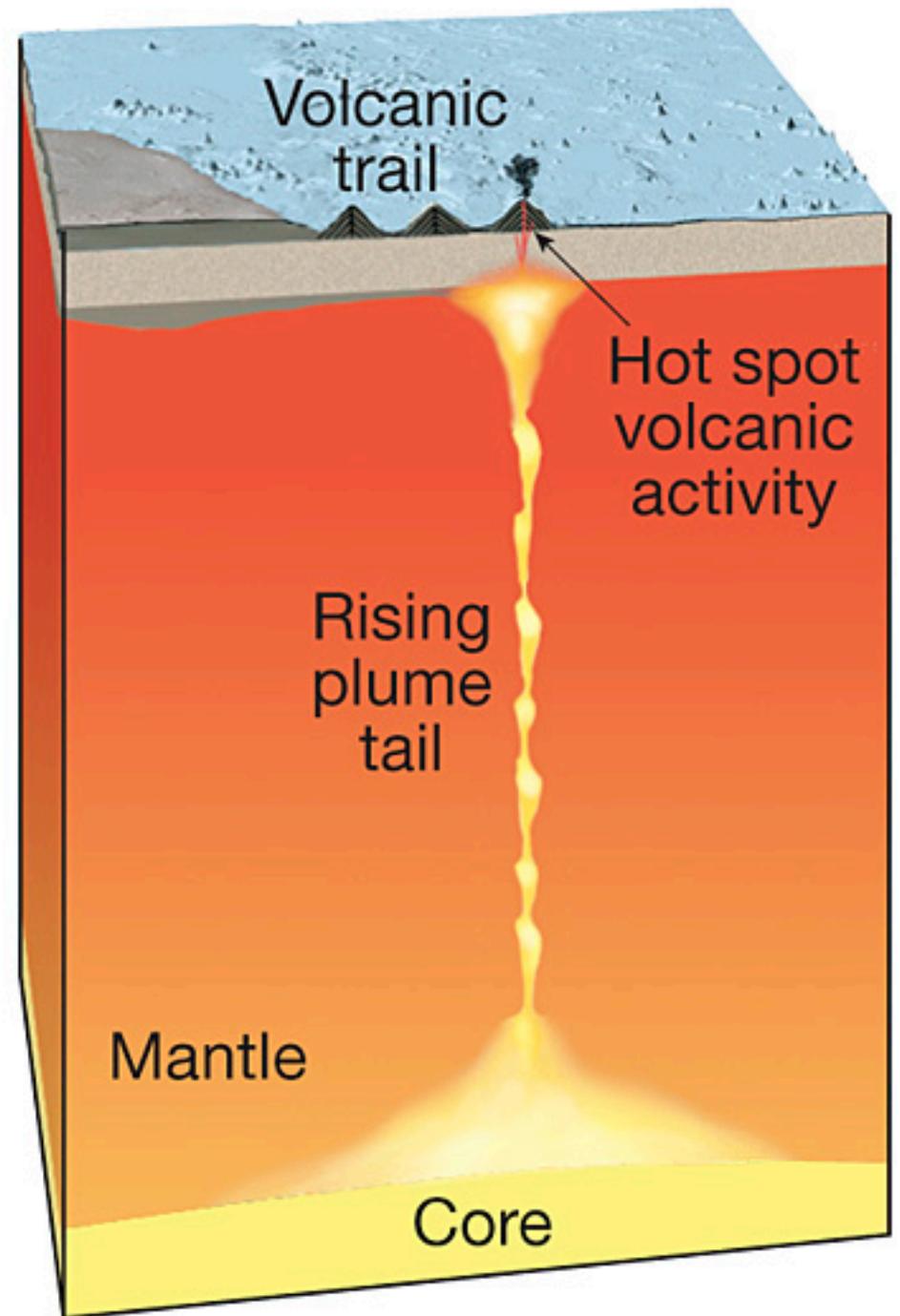
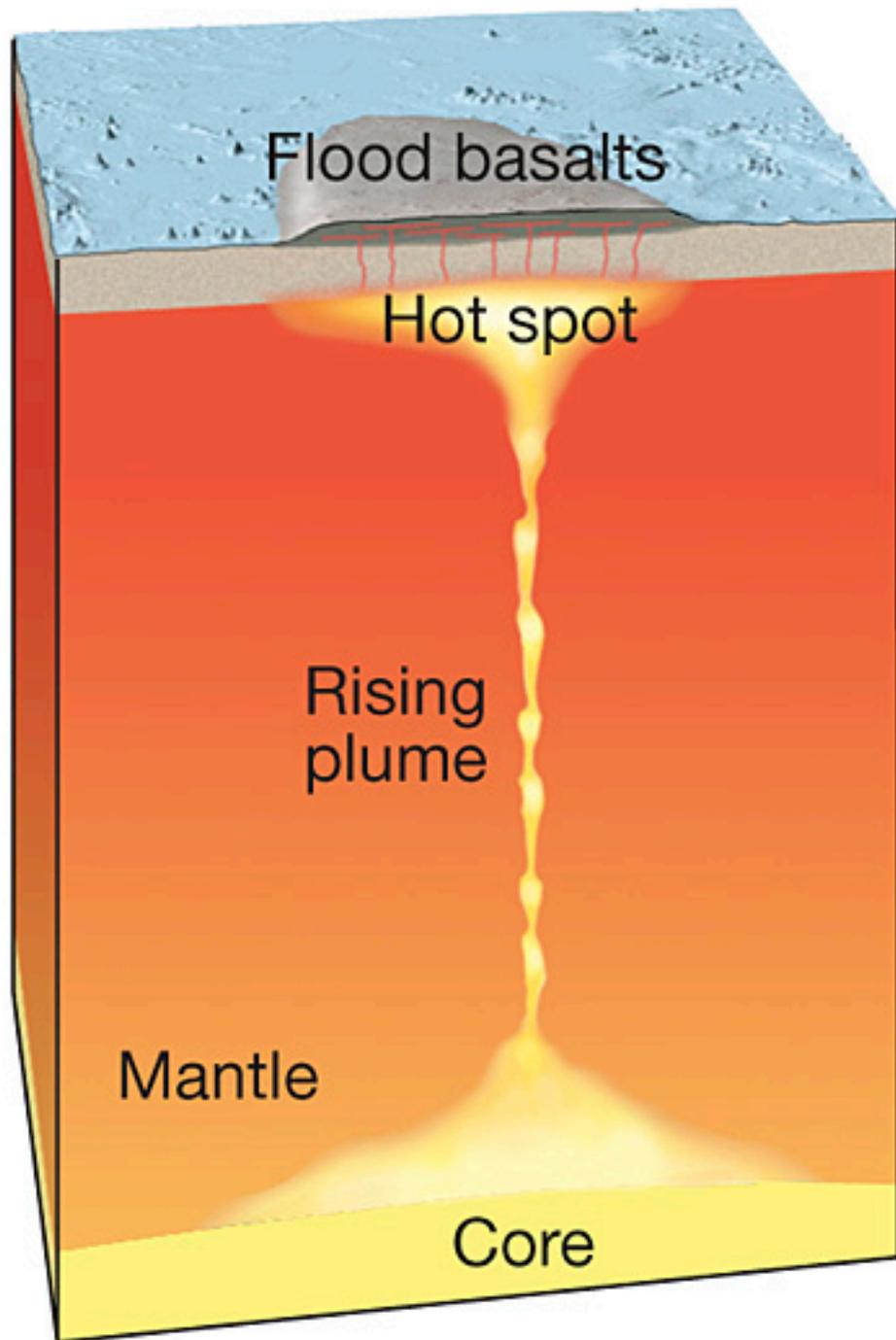
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B.

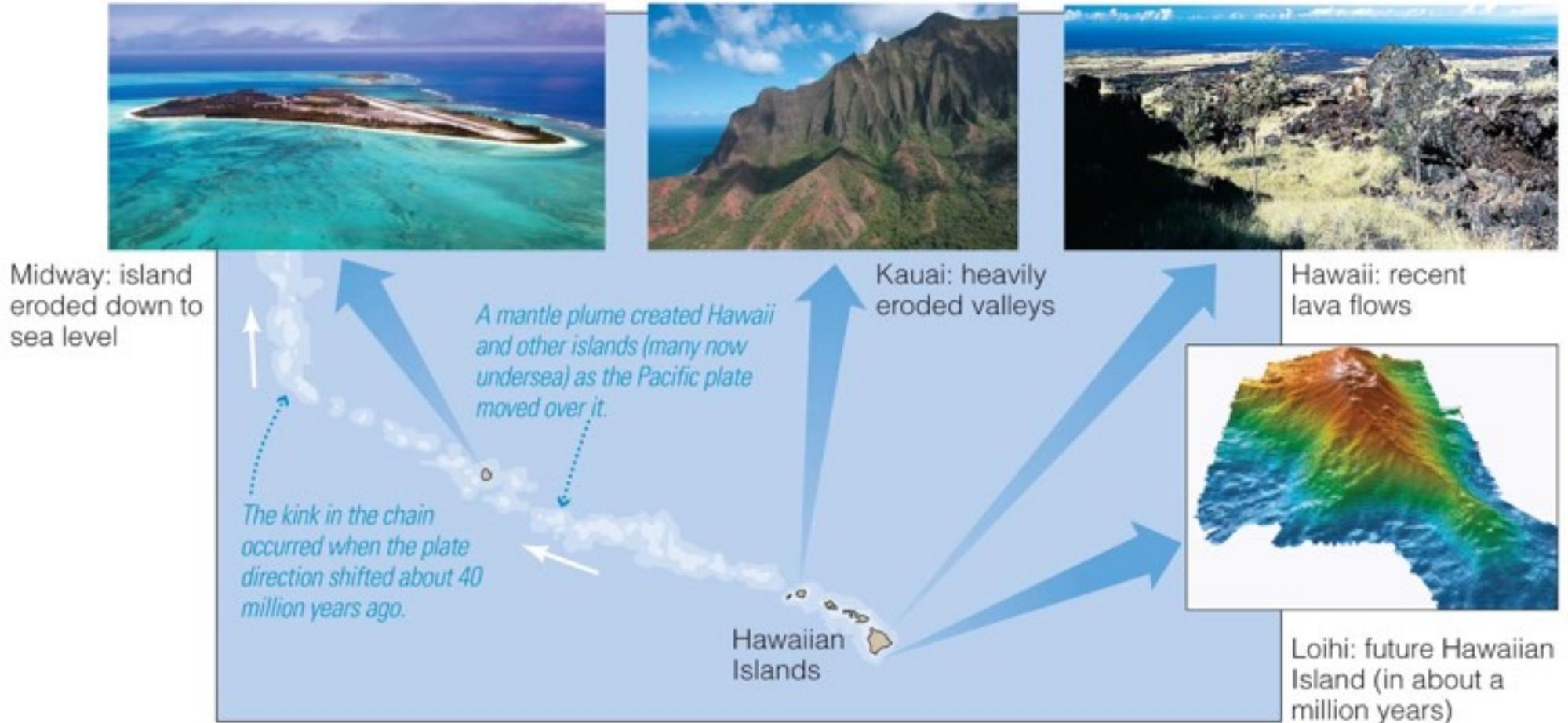
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Hot Spots



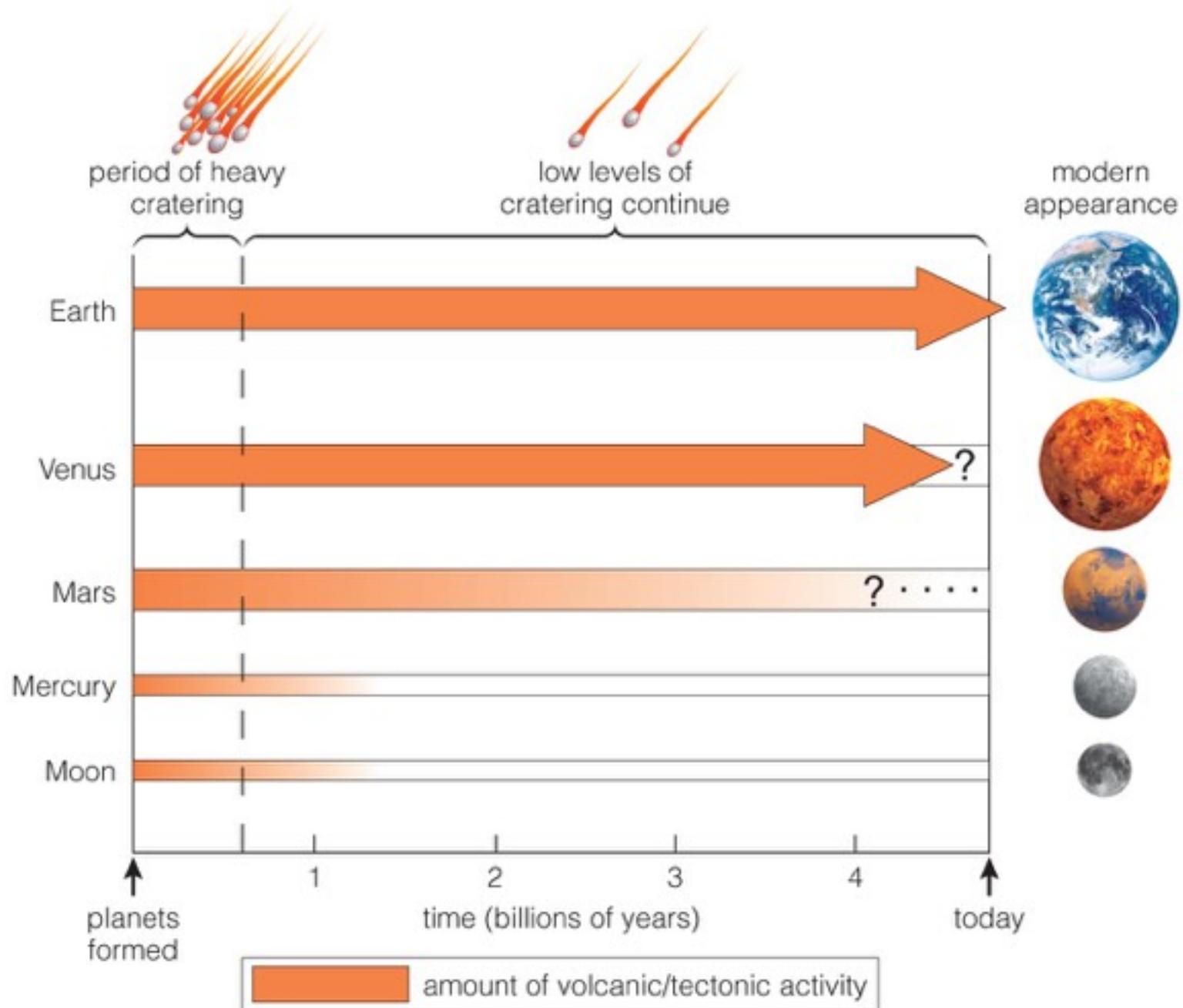
Hot Spots

Each Hawaiian Island starts as a growing volcano, goes extinct as the plate slides across the hot spot, then erodes back into the sea.

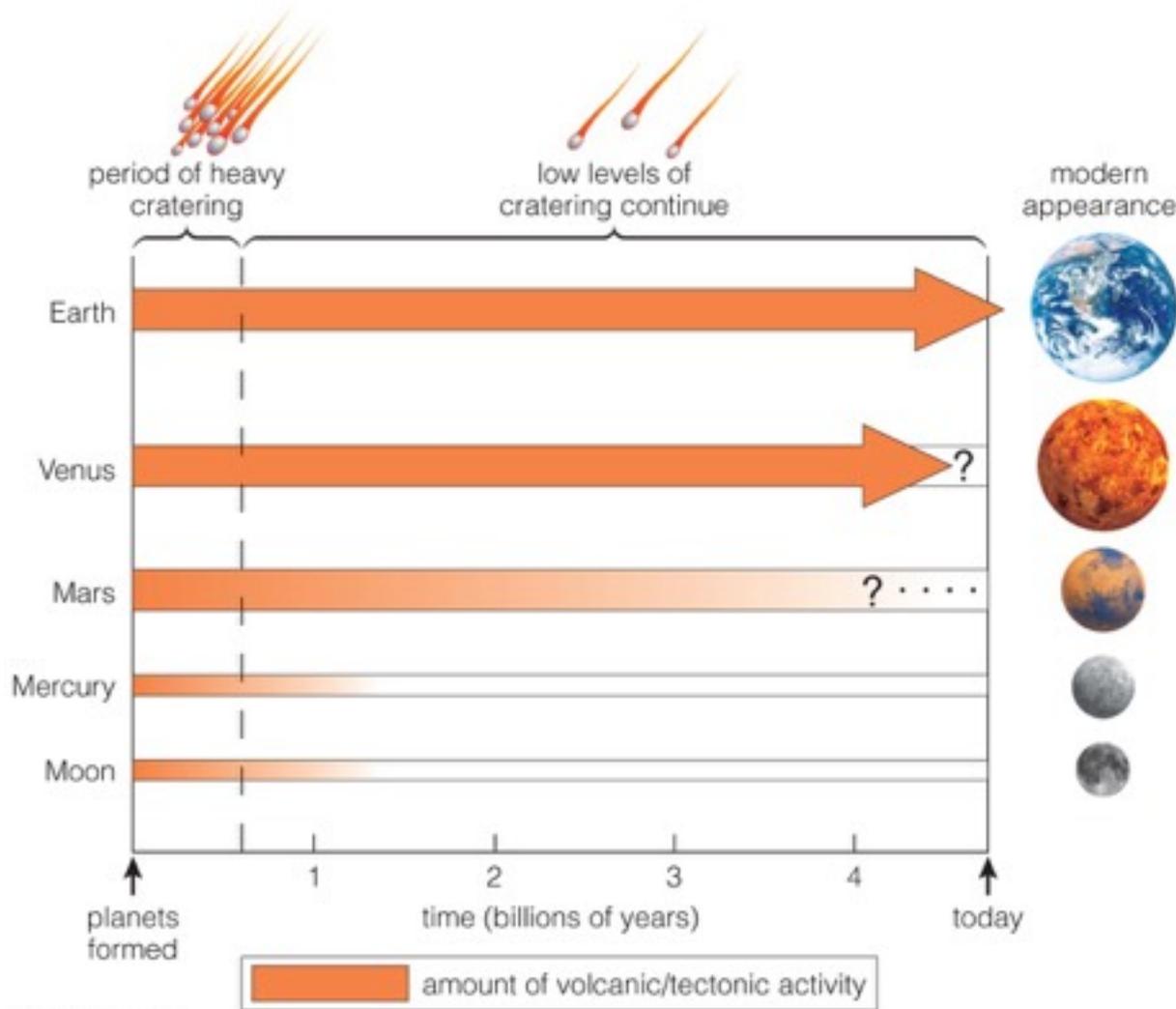


- The Hawaiian islands have formed where a plate is moving over a volcanic hot spot.

Was Earth's geology destined from birth?



Earth's Destiny



- Many of Earth's features are determined by its size, rotation, and distance from Sun.
- The reason for plate tectonics is not yet clear.

What have we learned?

- **How is Earth's surface shaped by plate tectonics?**
 - Measurements of plate motions confirm the idea of continental drift.
 - Plate tectonics is responsible for subduction, seafloor spreading, mountains, rifts, and earthquakes.

What have we learned?

- **Was Earth's geology destined from birth?**
 - Many of Earth's features are determined by its size, distance from Sun, and rotation rate.
 - The reason for plate tectonics is still a mystery.