Today

- Terrestrial Planet Geology

- individual cases

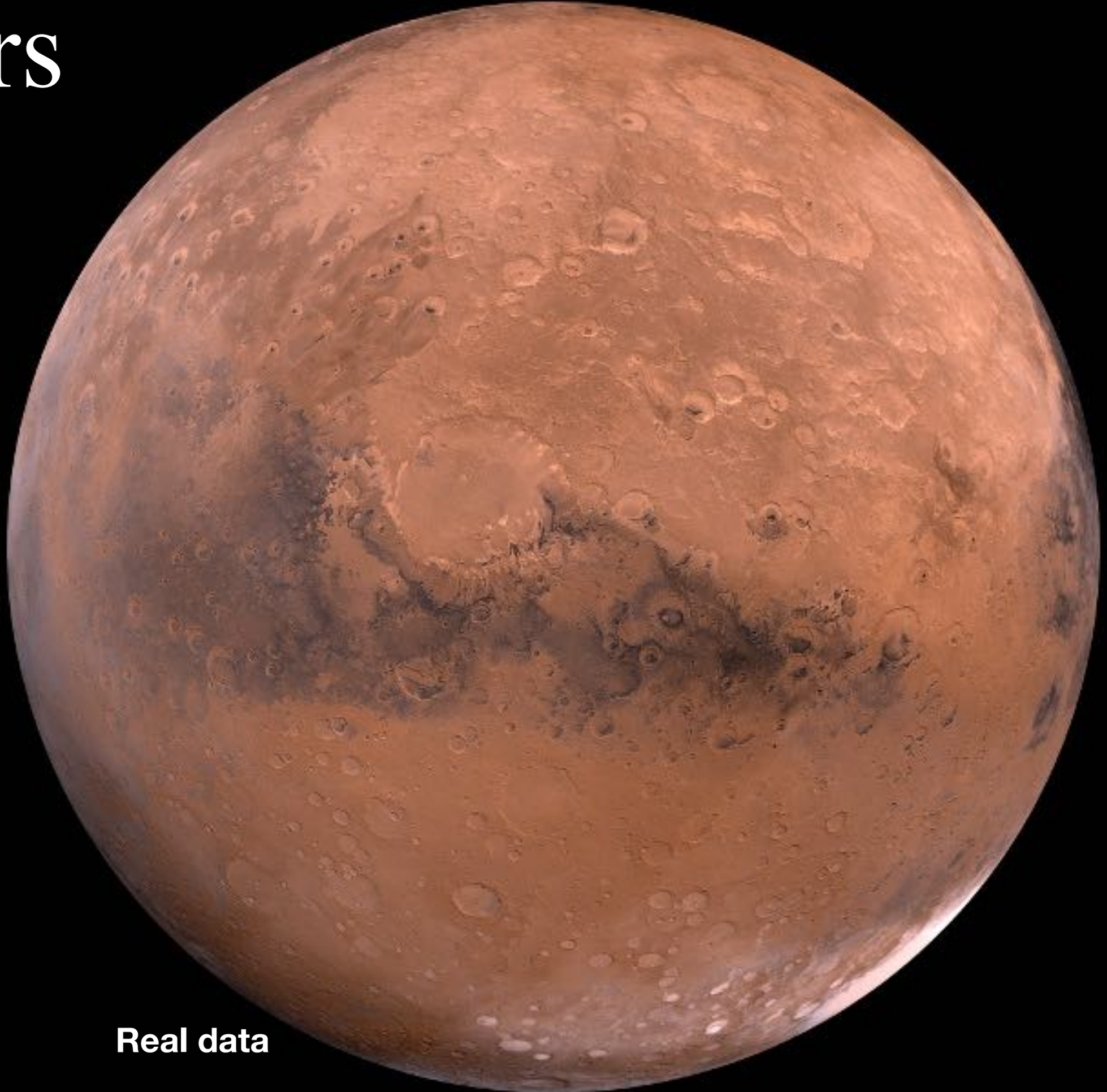
Events

- Homework 4 DUE

- Fall break next Tuesday

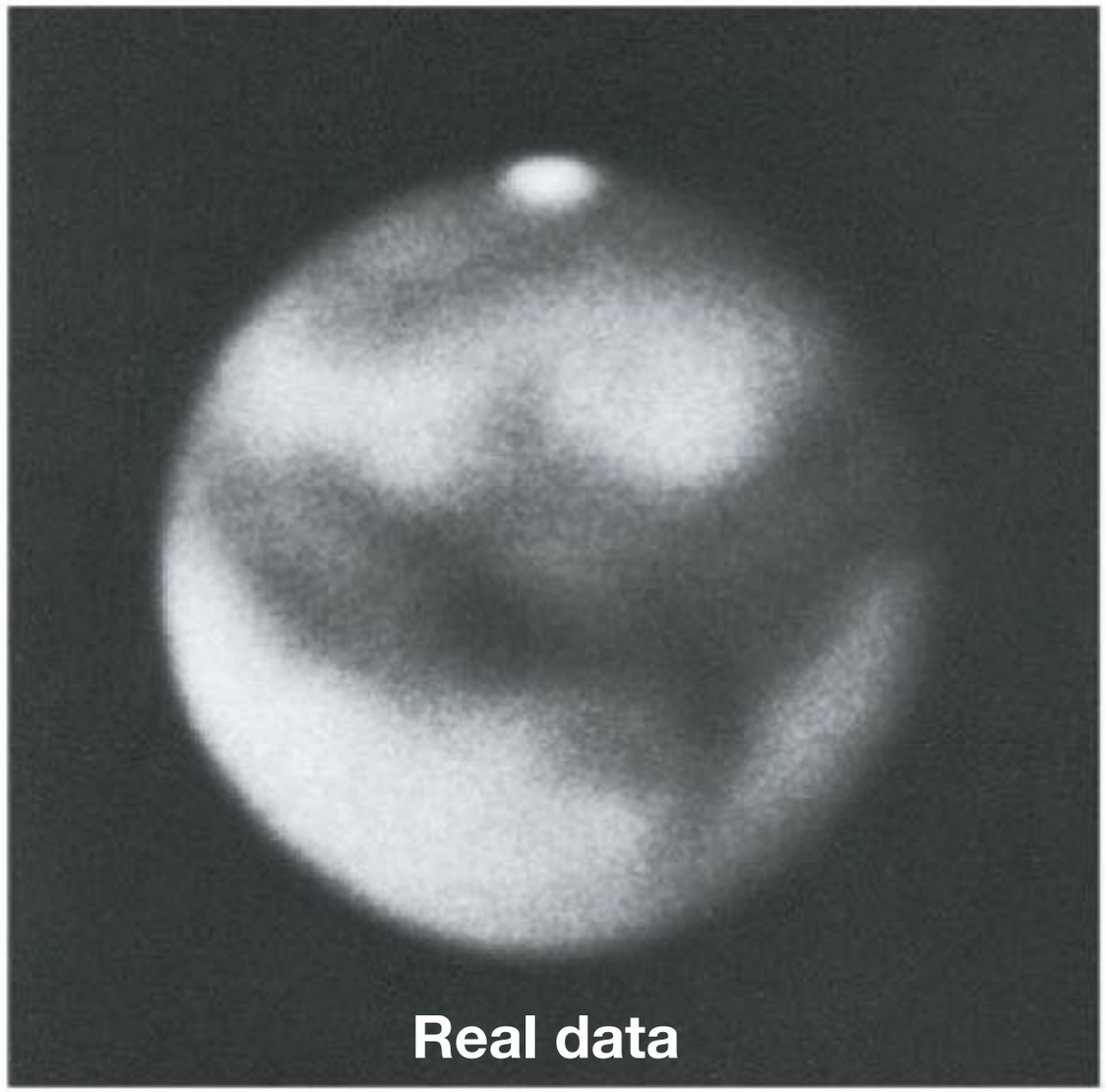
Artists's conception

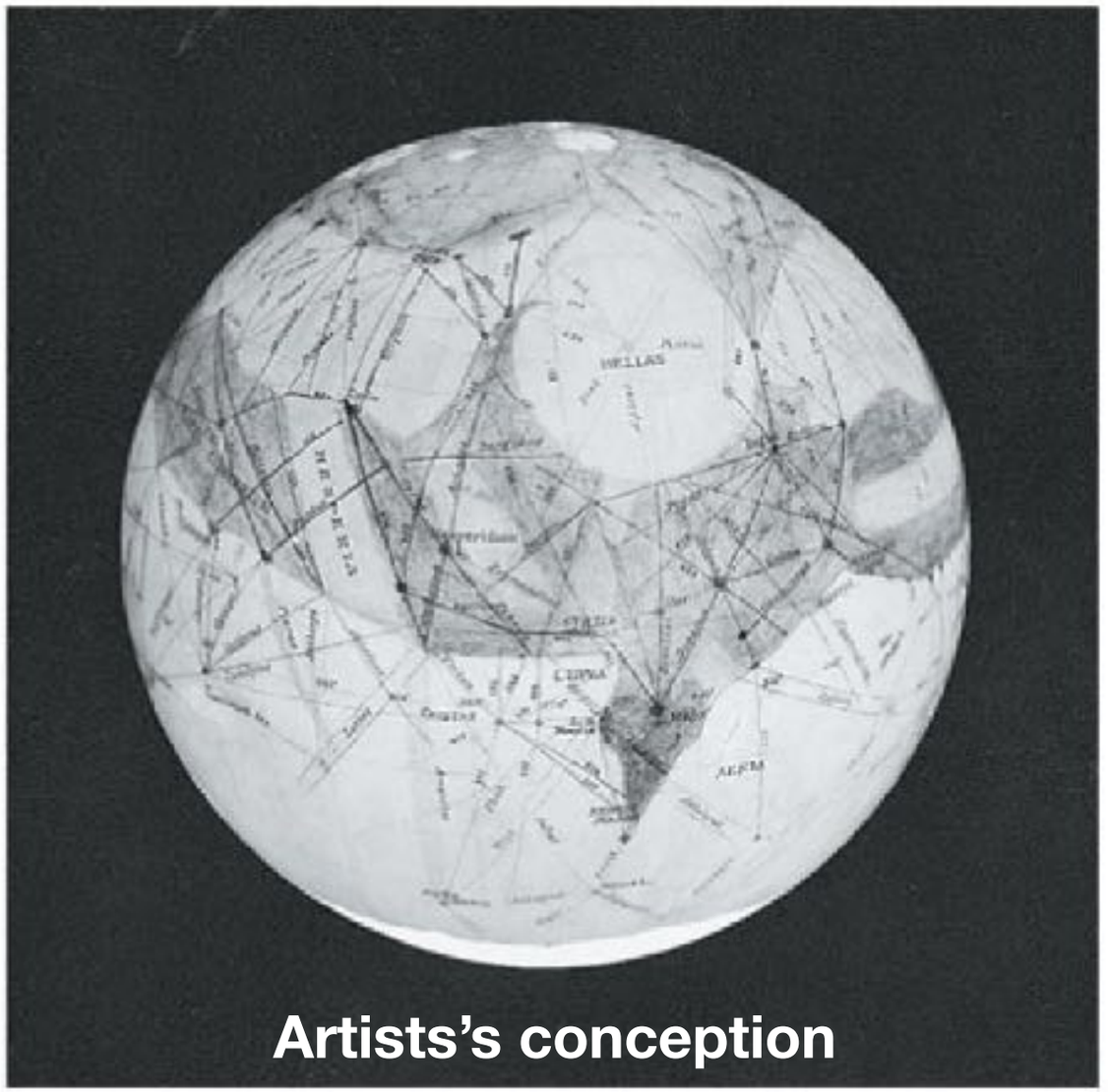
Mars



Real data

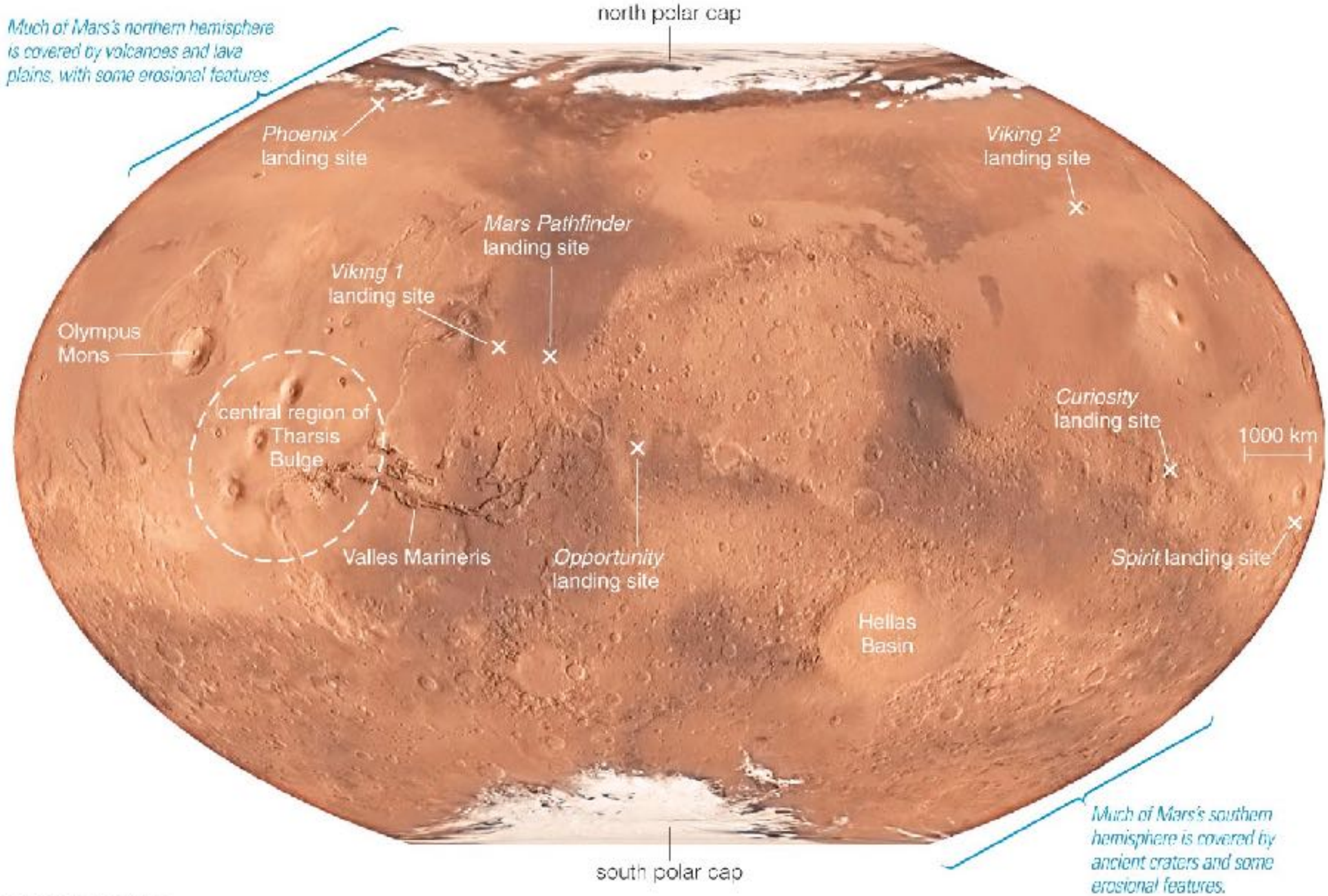
"Canals" on Mars



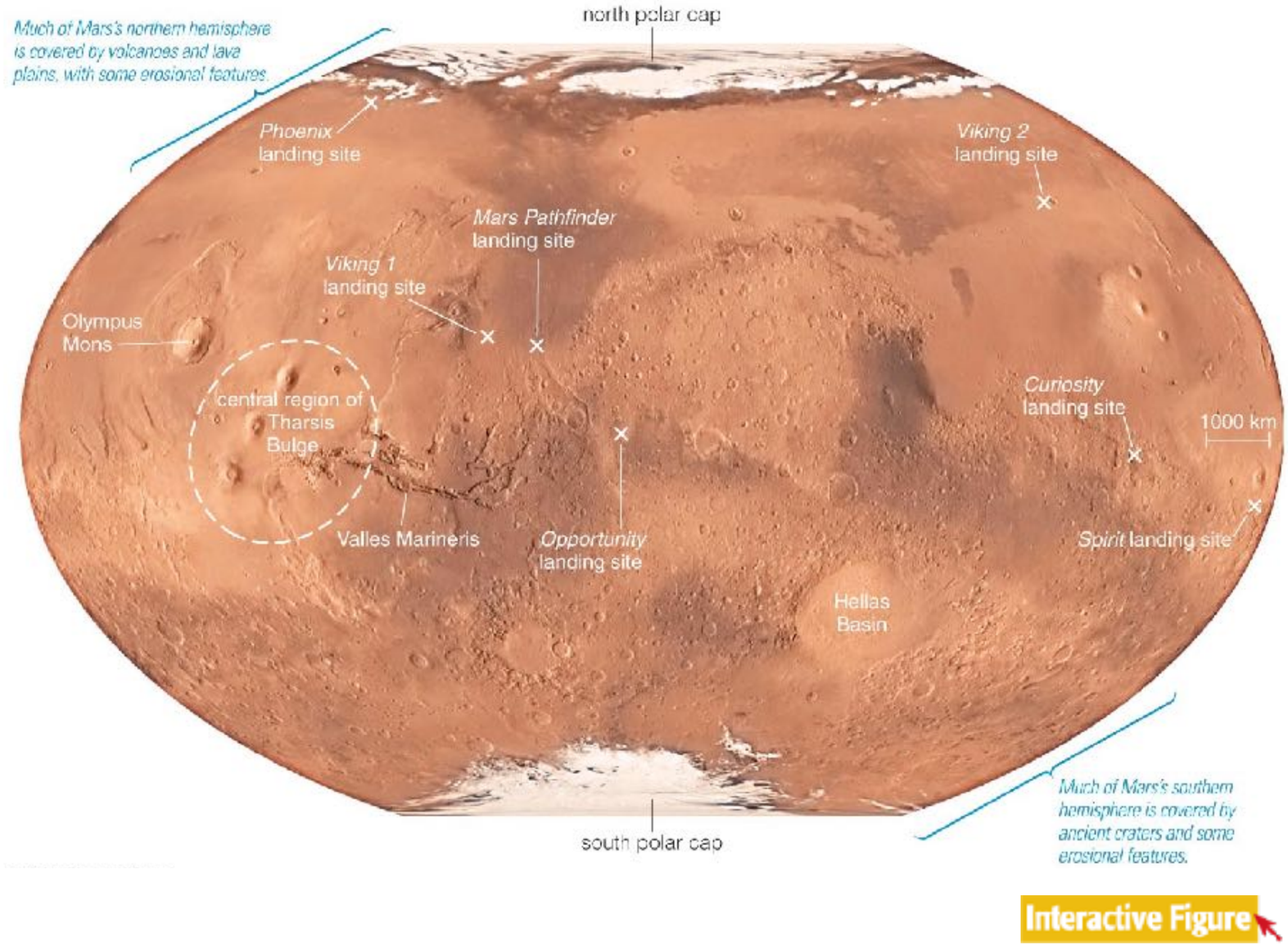


- Percival Lowell misinterpreted surface features seen in telescopic images of Mars.

What geological processes have shaped Mars?



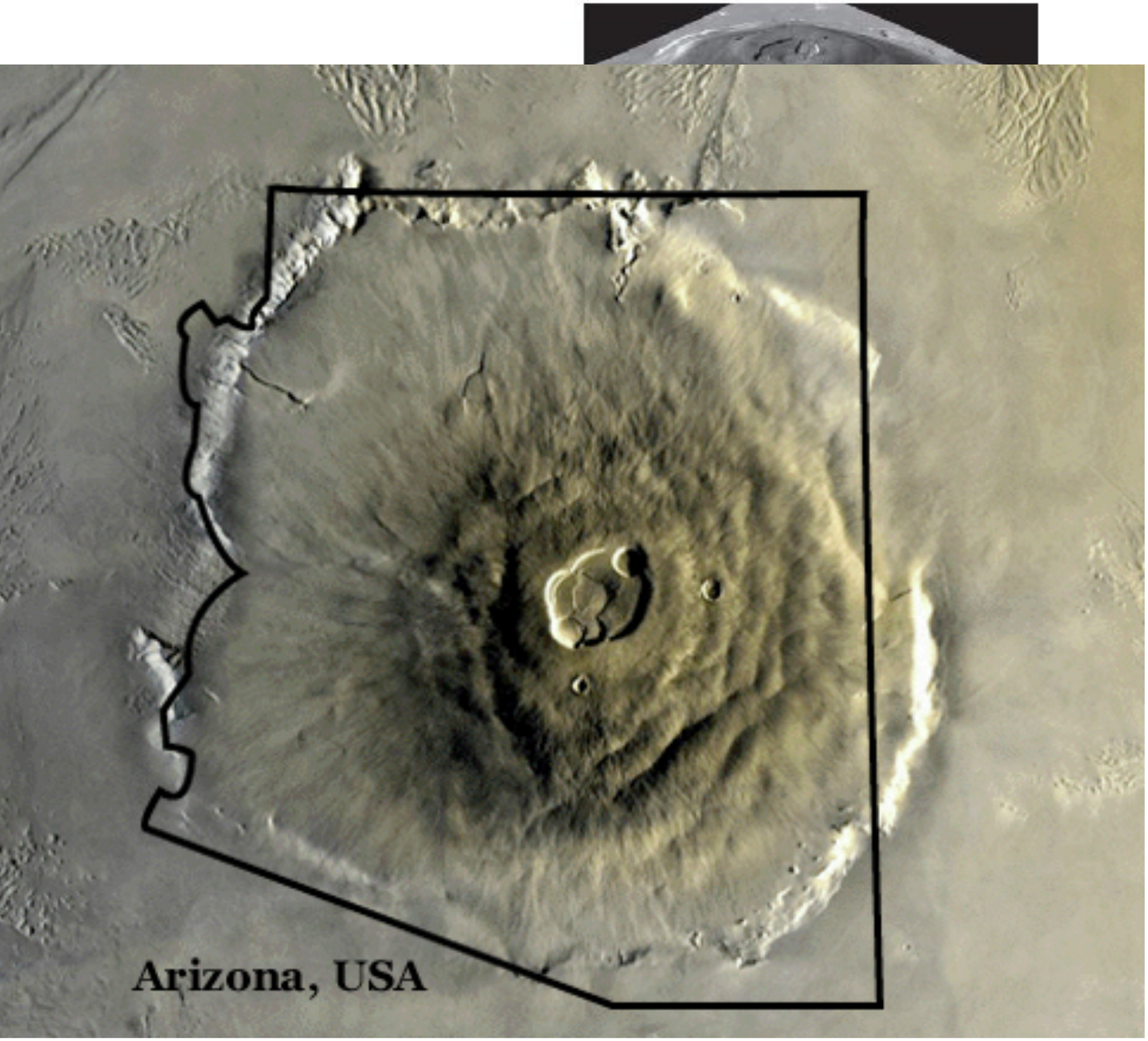
Cratering on Mars



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

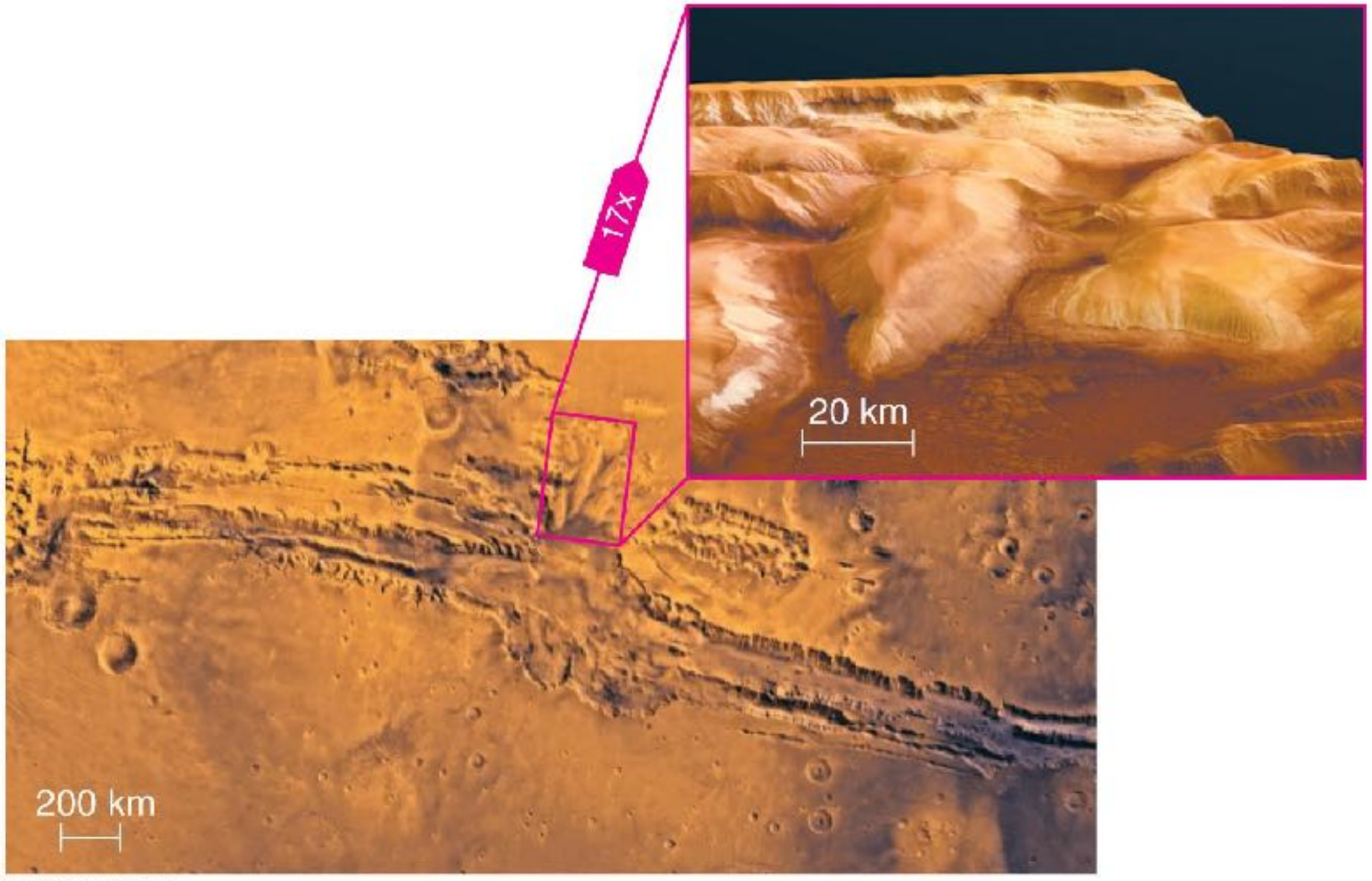
IF_09_25_MarsFeatures

Volcanism on Mars



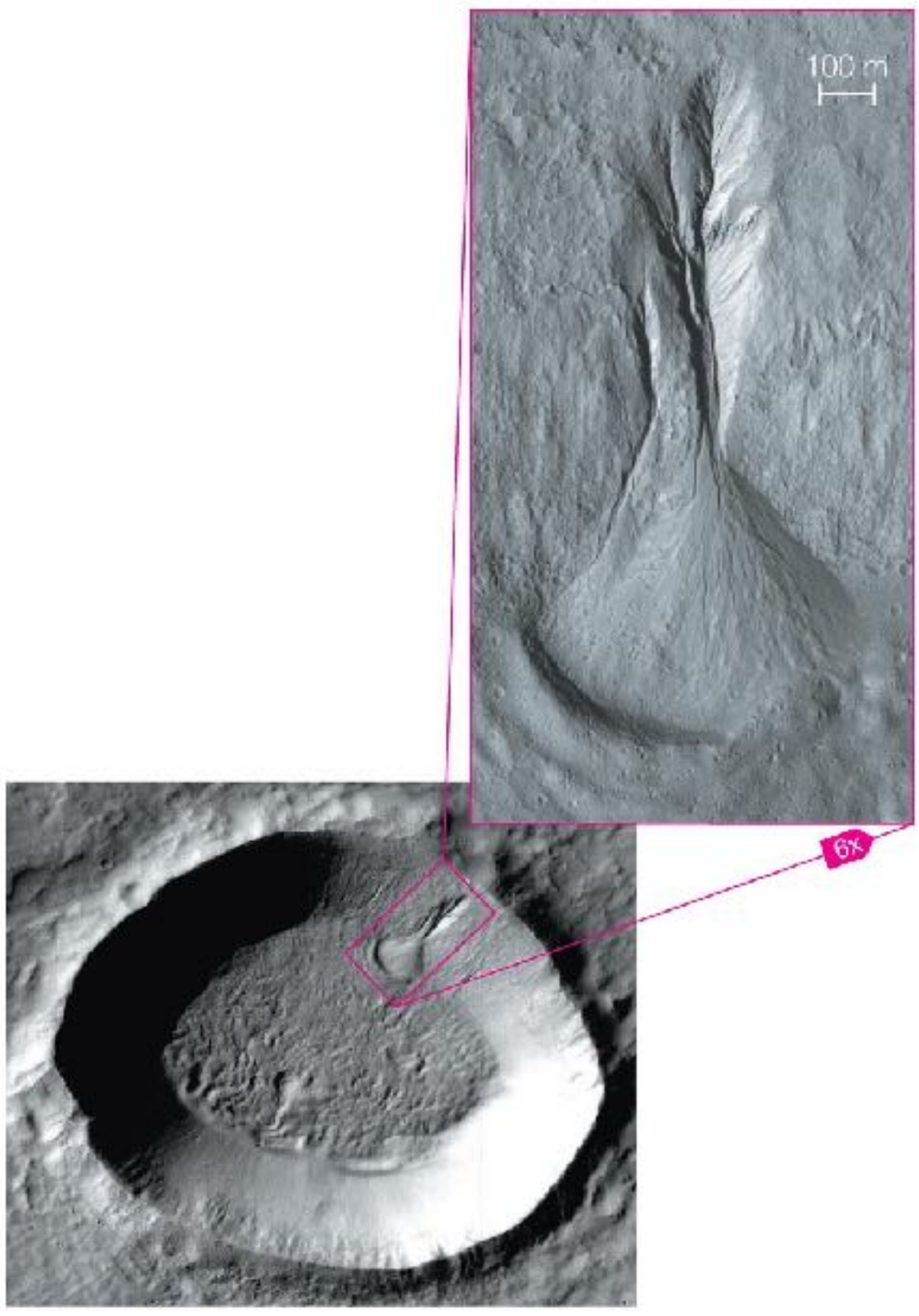
- Mars has many large shield volcanoes.
- Olympus Mons is largest volcano in solar system.

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?

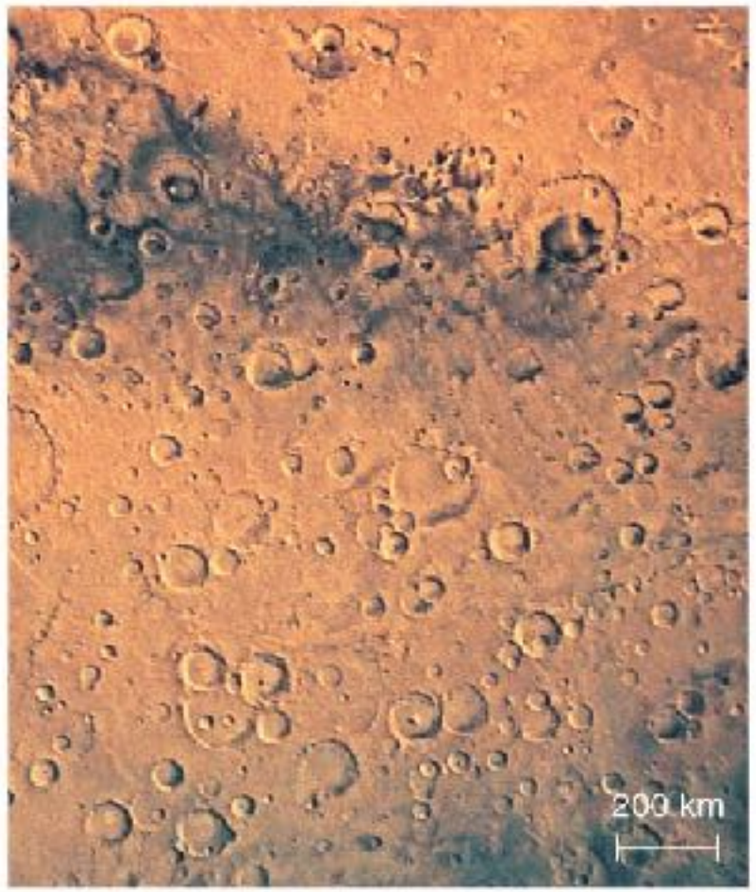


Dry Riverbeds?

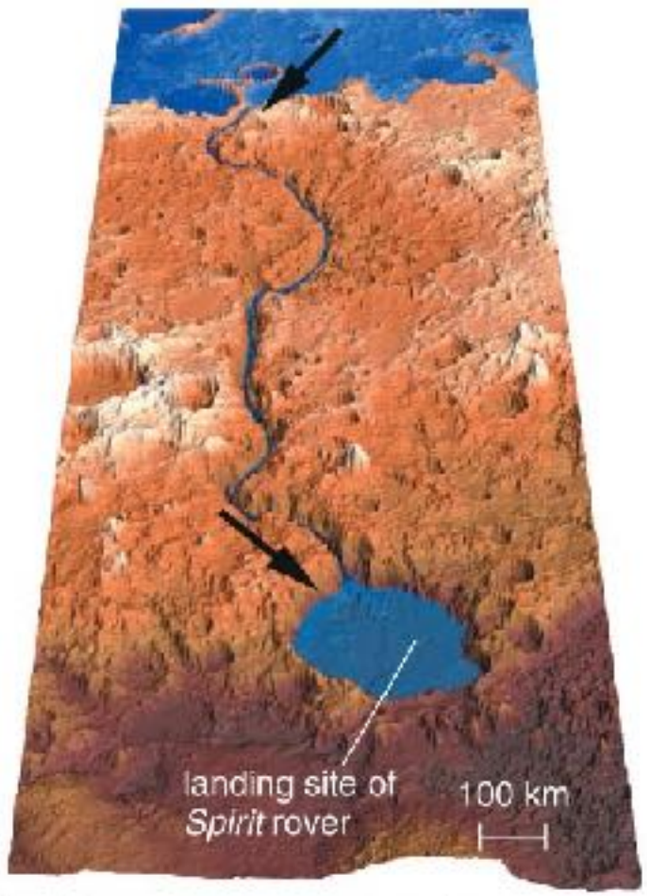
- Close-up photos of Mars show what appear to be dried-up riverbeds.

Erosion of Craters

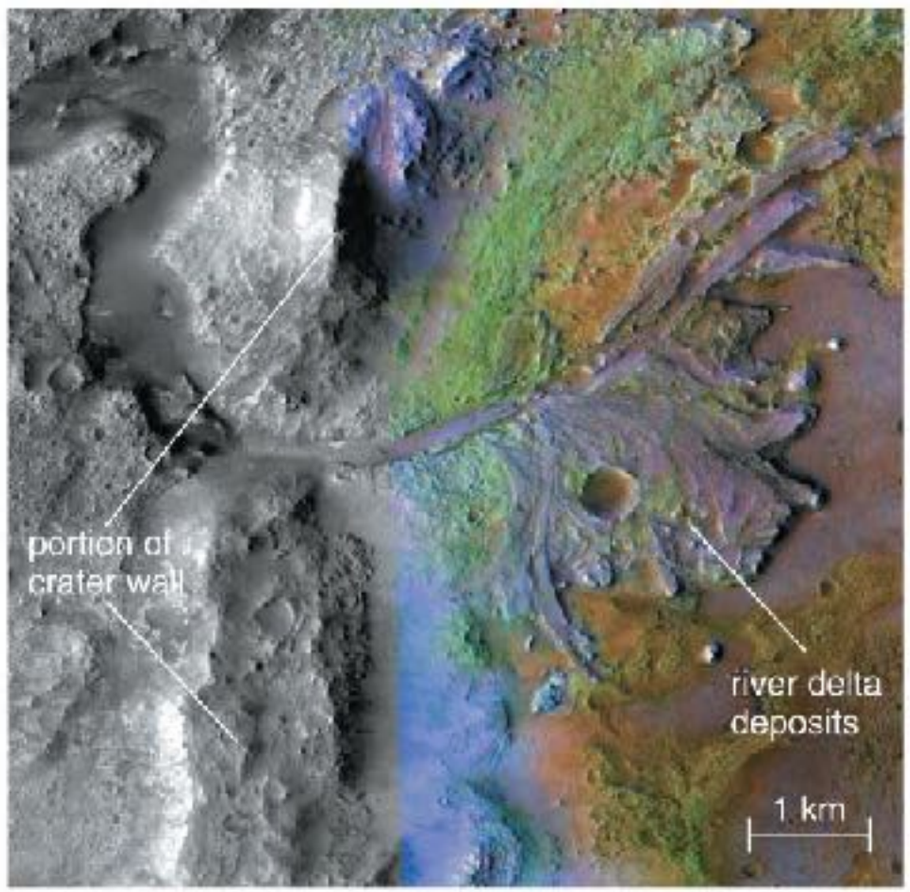
- Details of some craters suggest they were once filled with water.



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.

Rovers photoshopped together for scale

Spirit & Opportunity (2004)

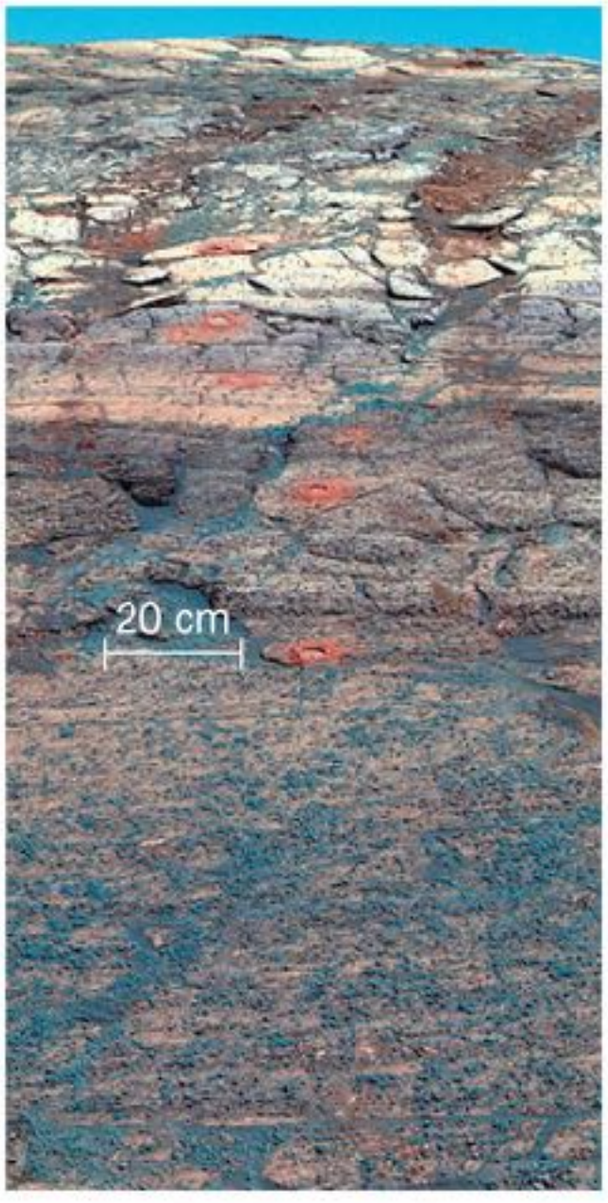
Curiosity (2012)

Pathfinder (1997)

https://www.youtube.com/watch?v=5-cBjI2zgB0

Pathfinder landing video

Martian Rocks



Mars (Endurance Crater)

Earth (Utah)

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

Martian Rocks

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

centimeters
0 10 20 30 40 50

Whale Rock

Hydrogen Content

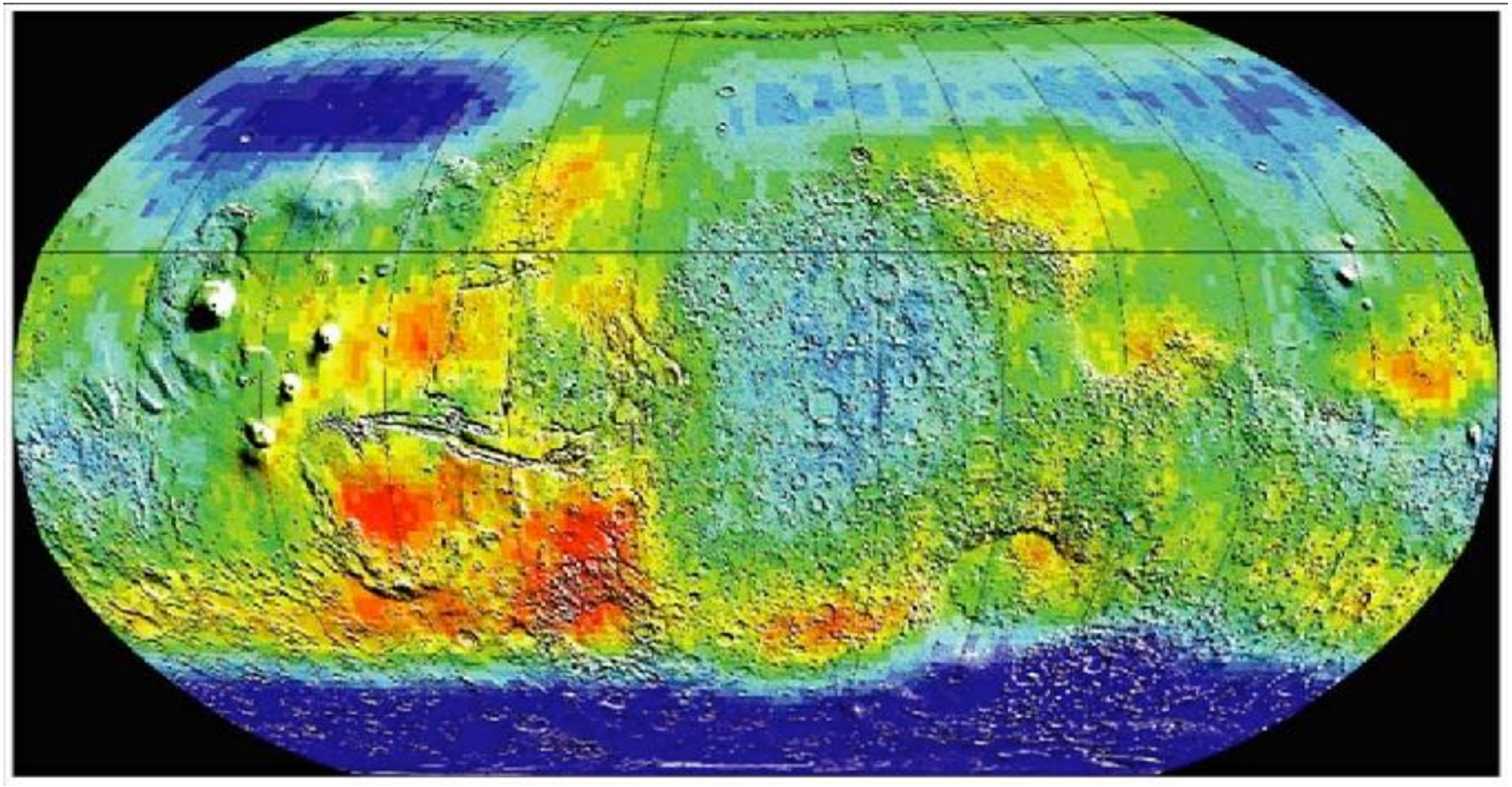


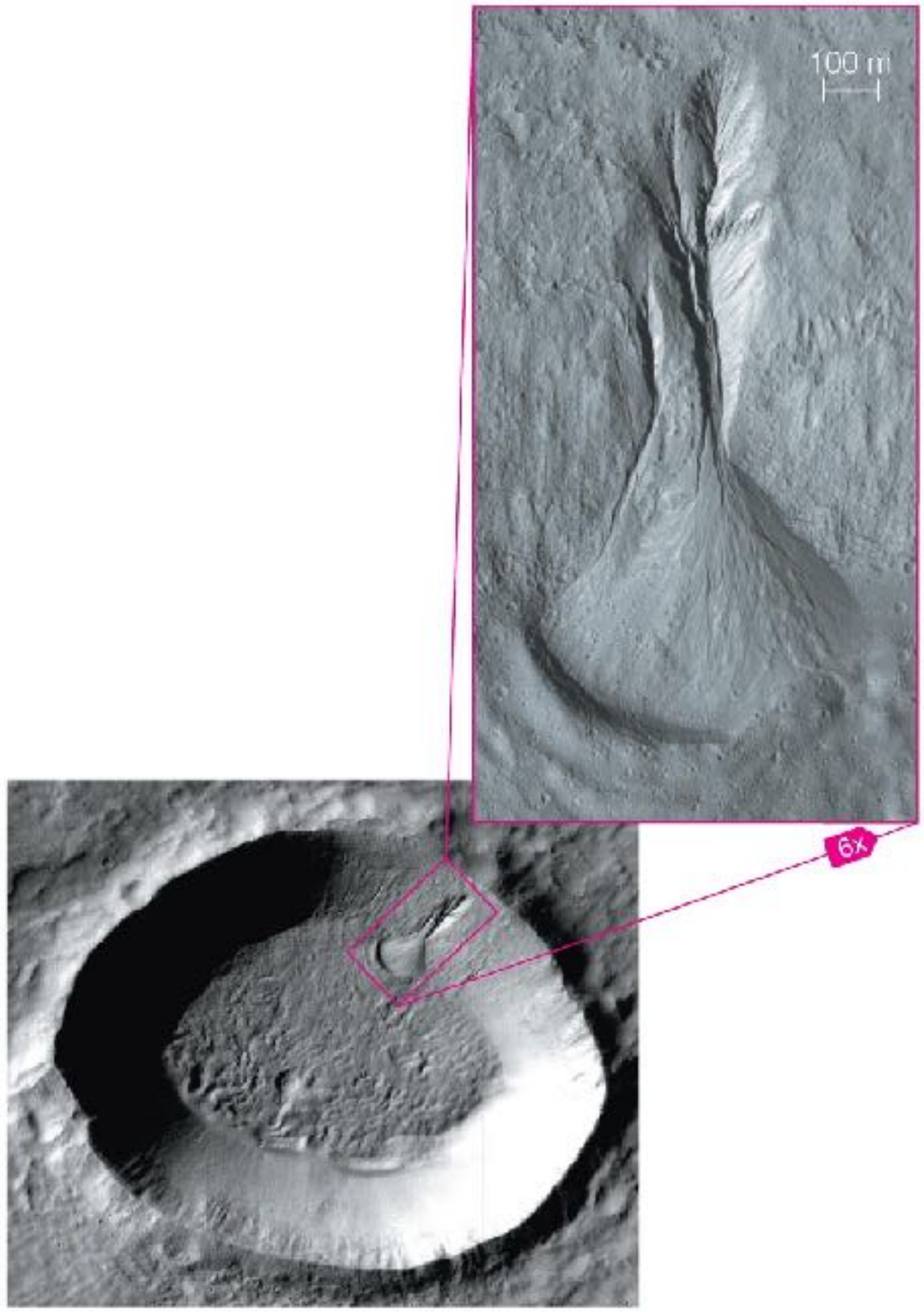
Image Credit: NASA/JPL

- 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.

- or, like, now

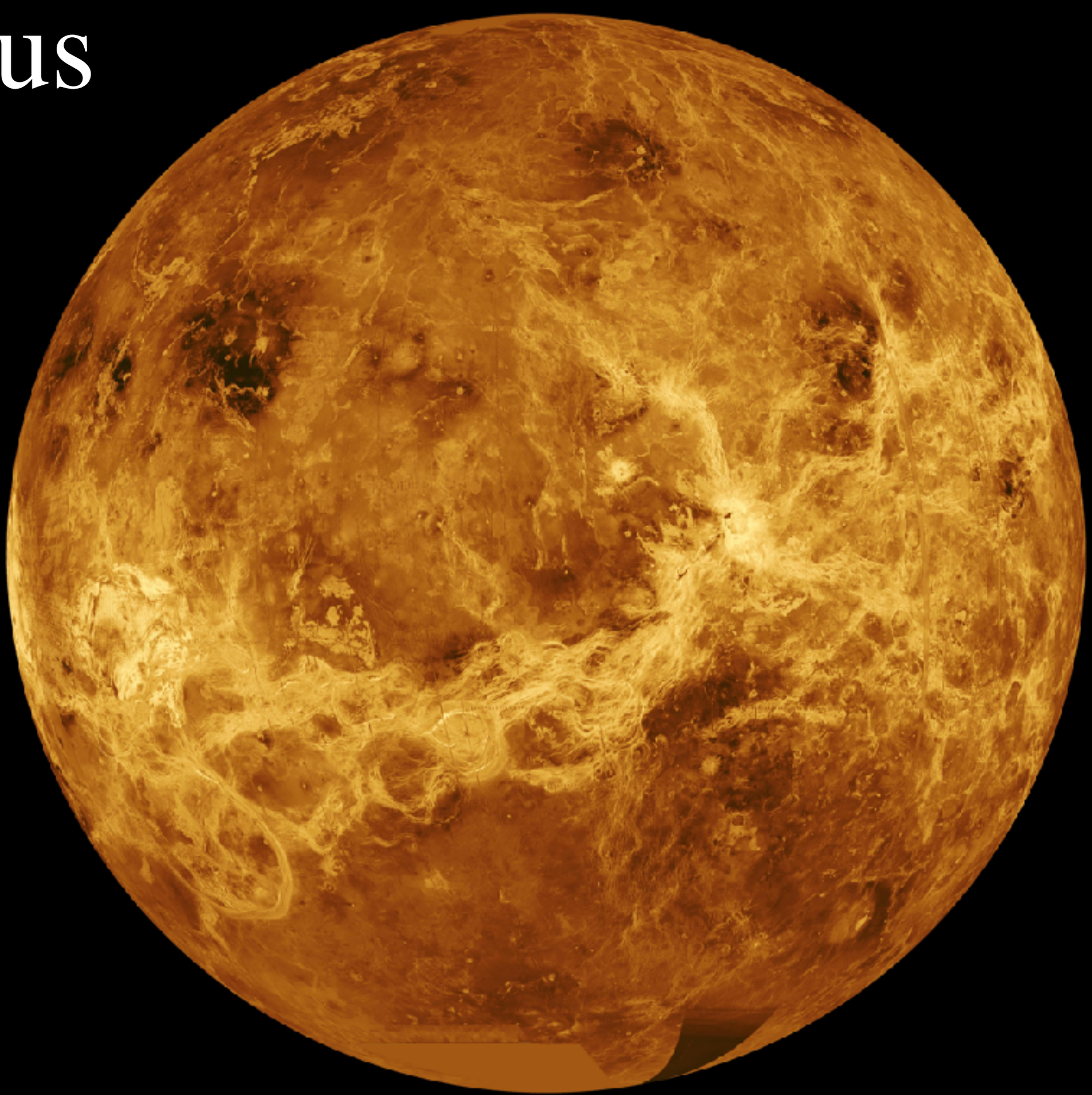


https://static01.nyt.com/newsgraphics/2015/09/28/mars-water/d910b431eb0ab62d9a5542dd1c10f5373df35383/images/flows.gif

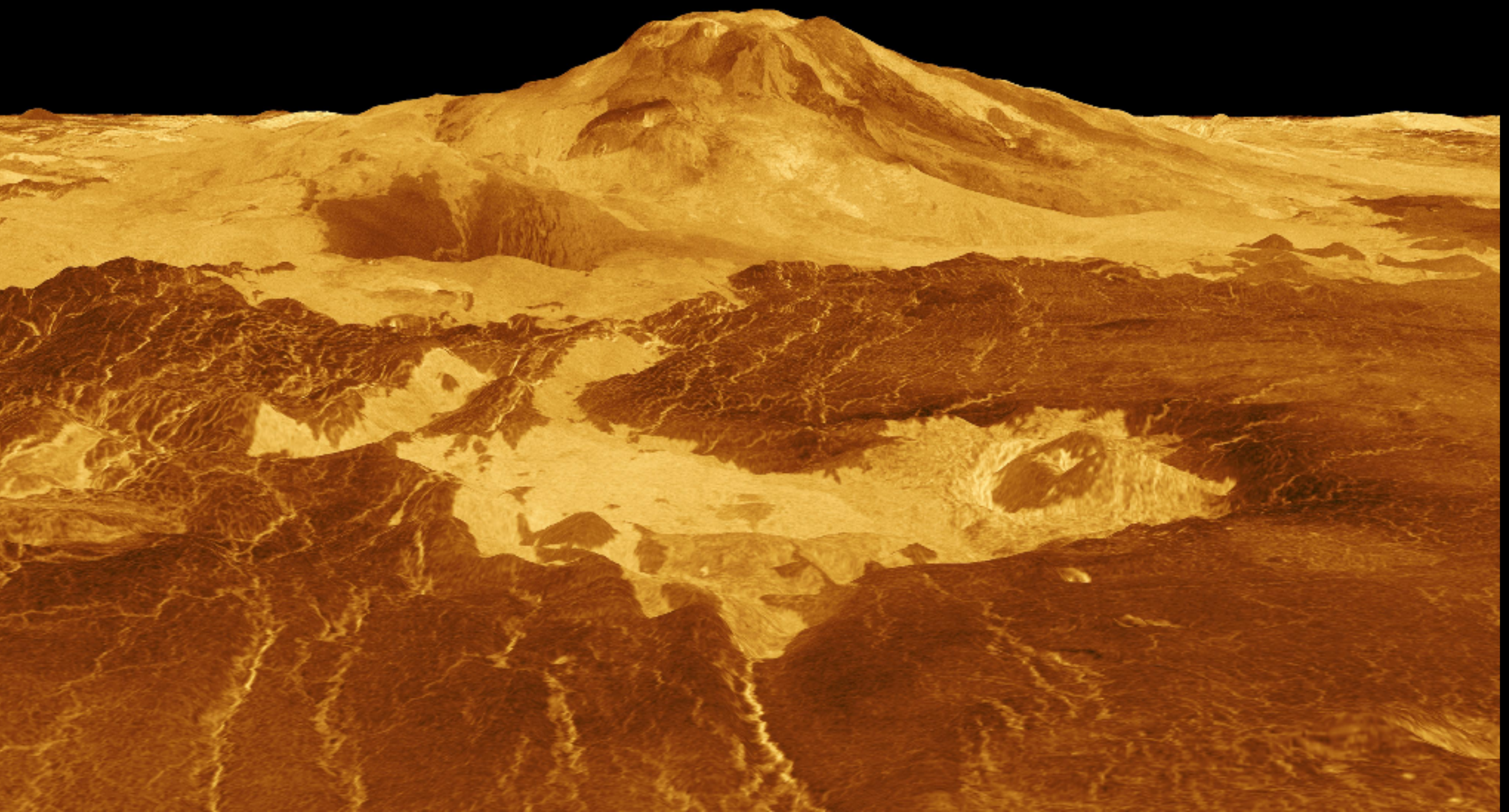
- Major geological features of Mars
  - Differences in cratering across surface
  - Giant shield volcanoes
  - Evidence of tectonic activity
- Evidence that water once flowed on Mars
  - Some surface features look like dry riverbeds.
  - Some craters appear to be eroded.
  - Rovers have found rocks composed of minerals that form in water.
  - Gullies in crater walls may indicate recent water flows.

https://www.nasa.gov/mission_pages/msl/images/index.html

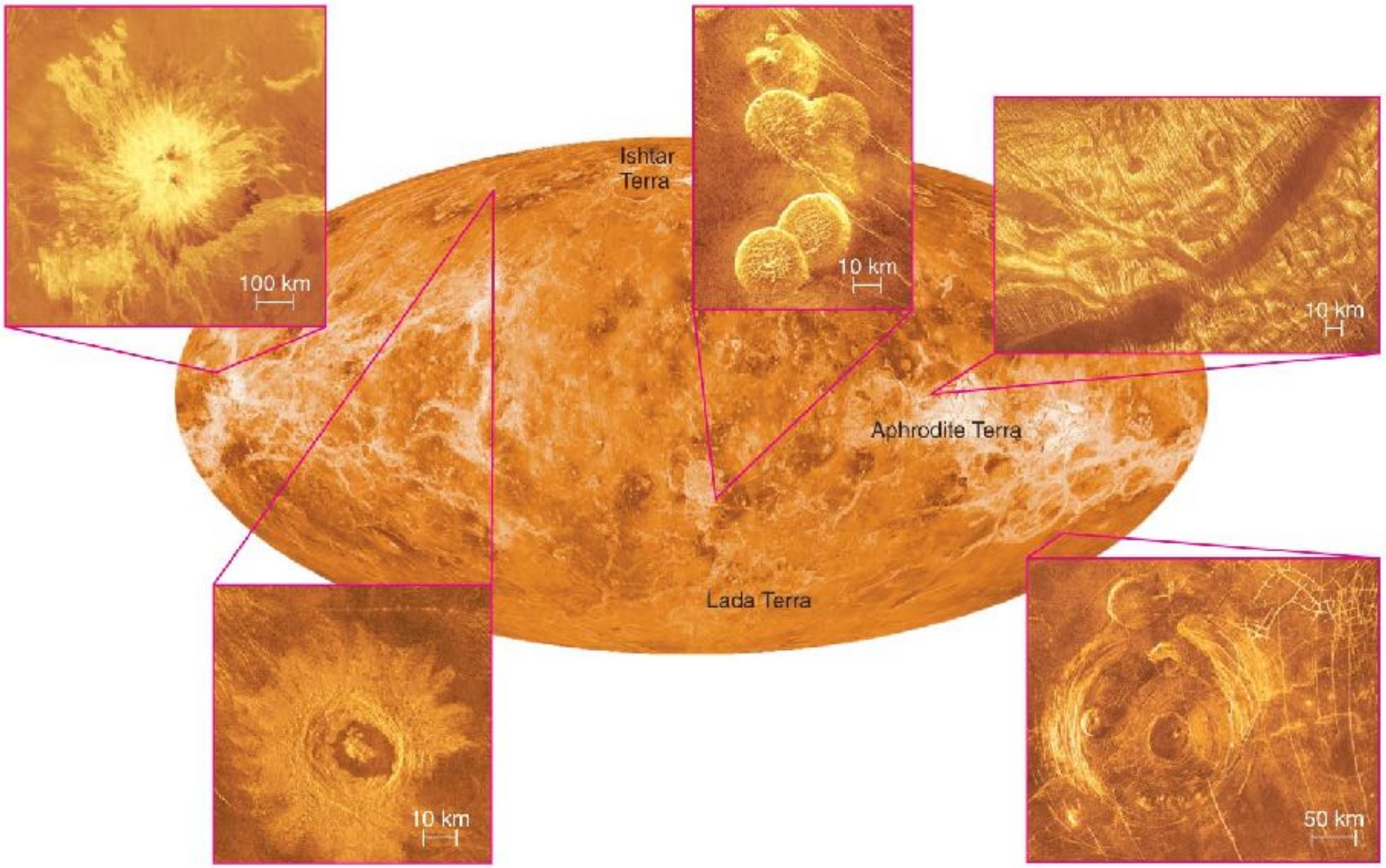
Venus



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

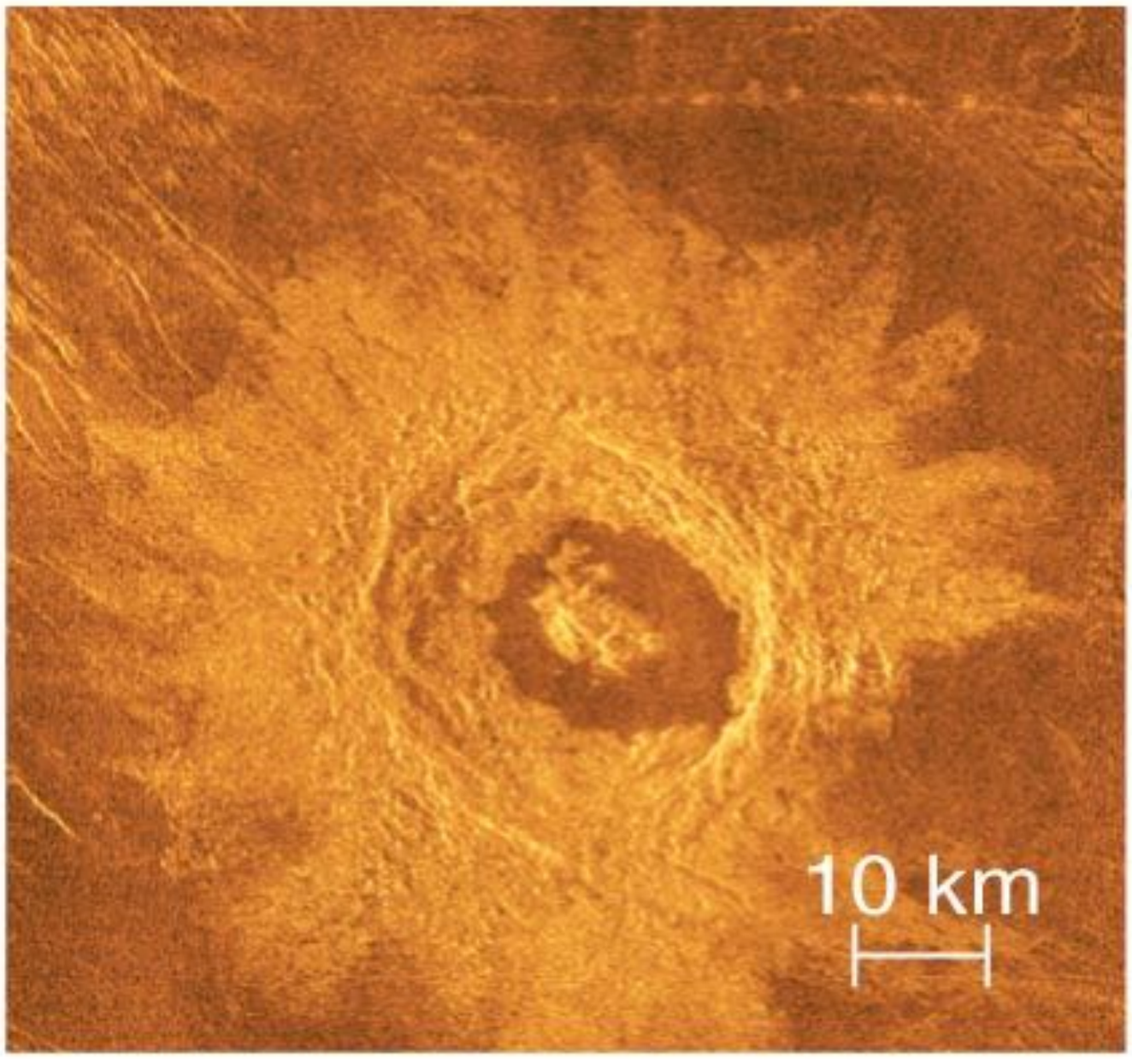


What geological processes have shaped Venus?



https://www.youtube.com/watch?v=Ub_bBs_oh_c

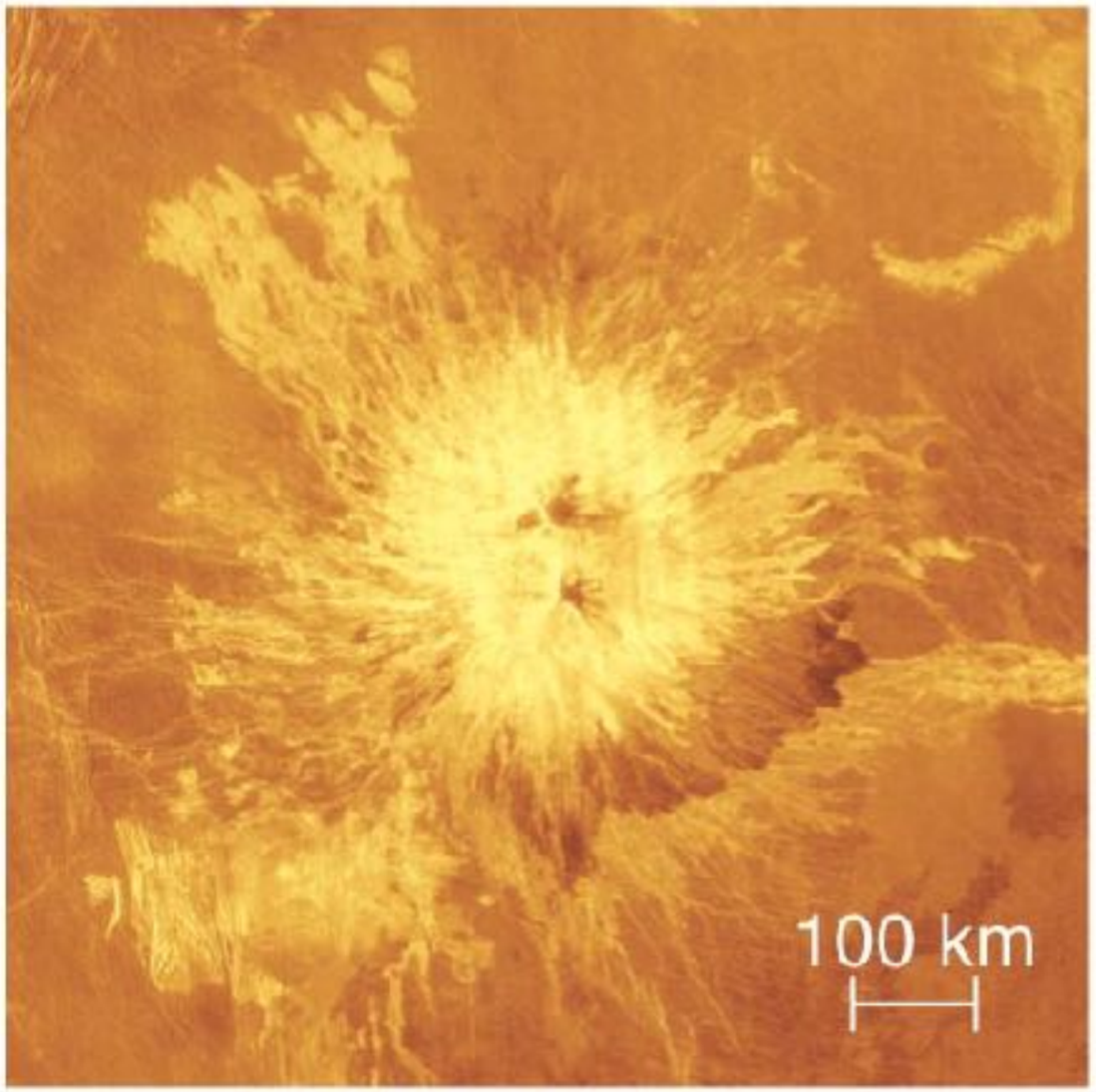
Cratering on Venus



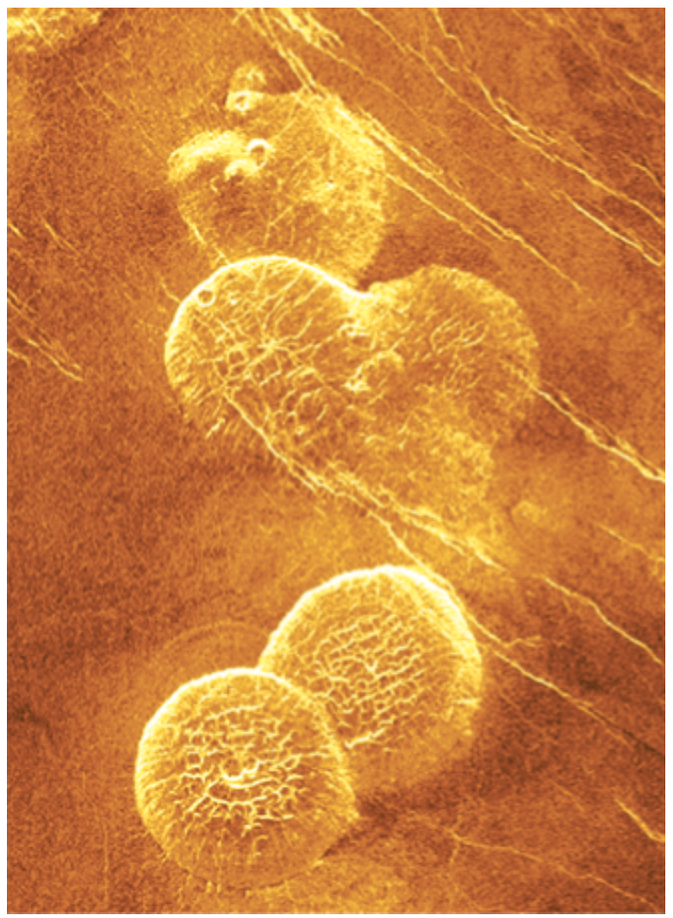
- Venus has impact craters, but fewer than the Moon, Mercury, or Mars.

- Mostly large craters
  - shielded from small impactors by thick atmosphere

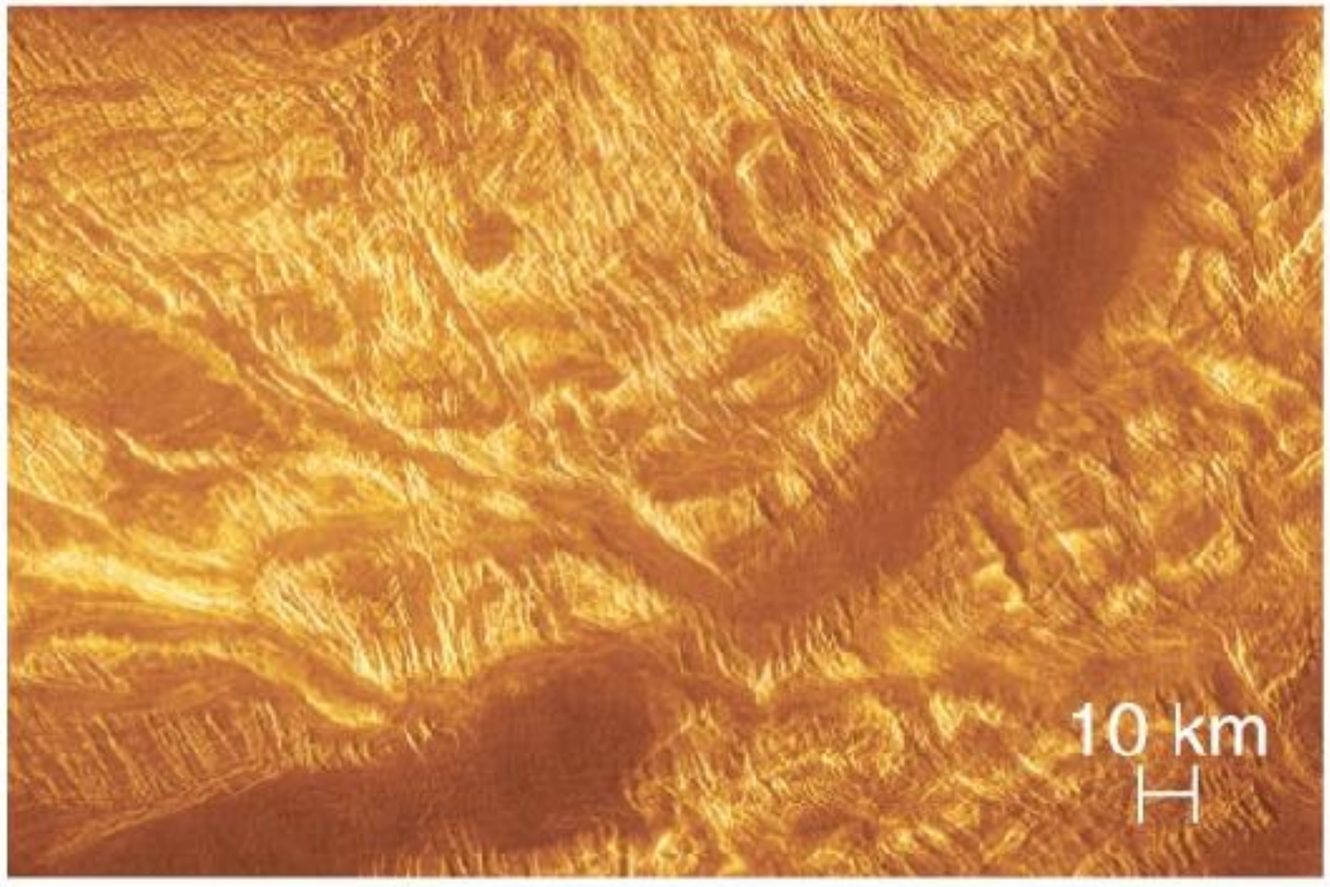
Volcanoes on Venus



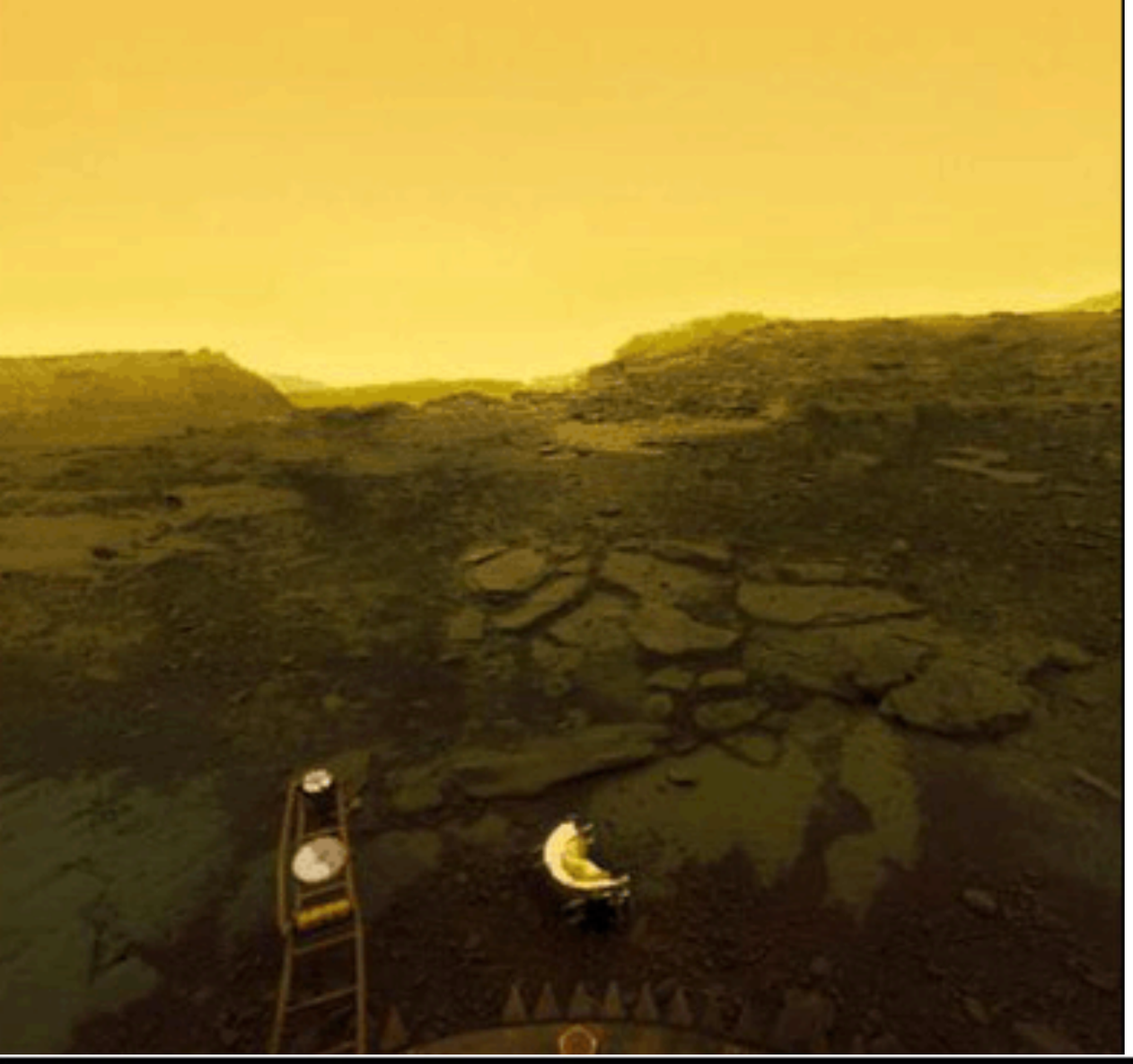
- It has many volcanoes, including both shield volcanoes and stratovolcanoes.

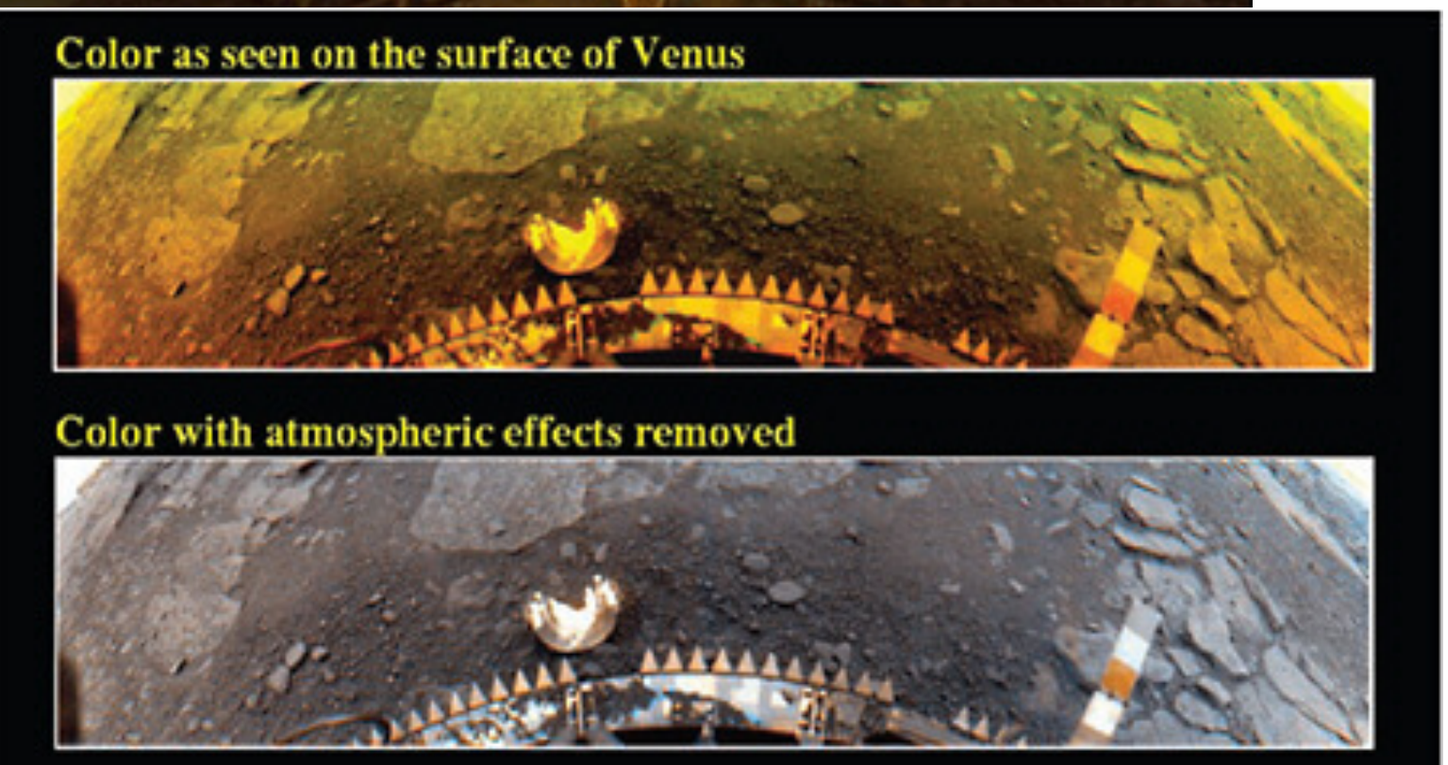


Tectonics on Venus



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





- Photos of rocks taken by landers show little erosion.

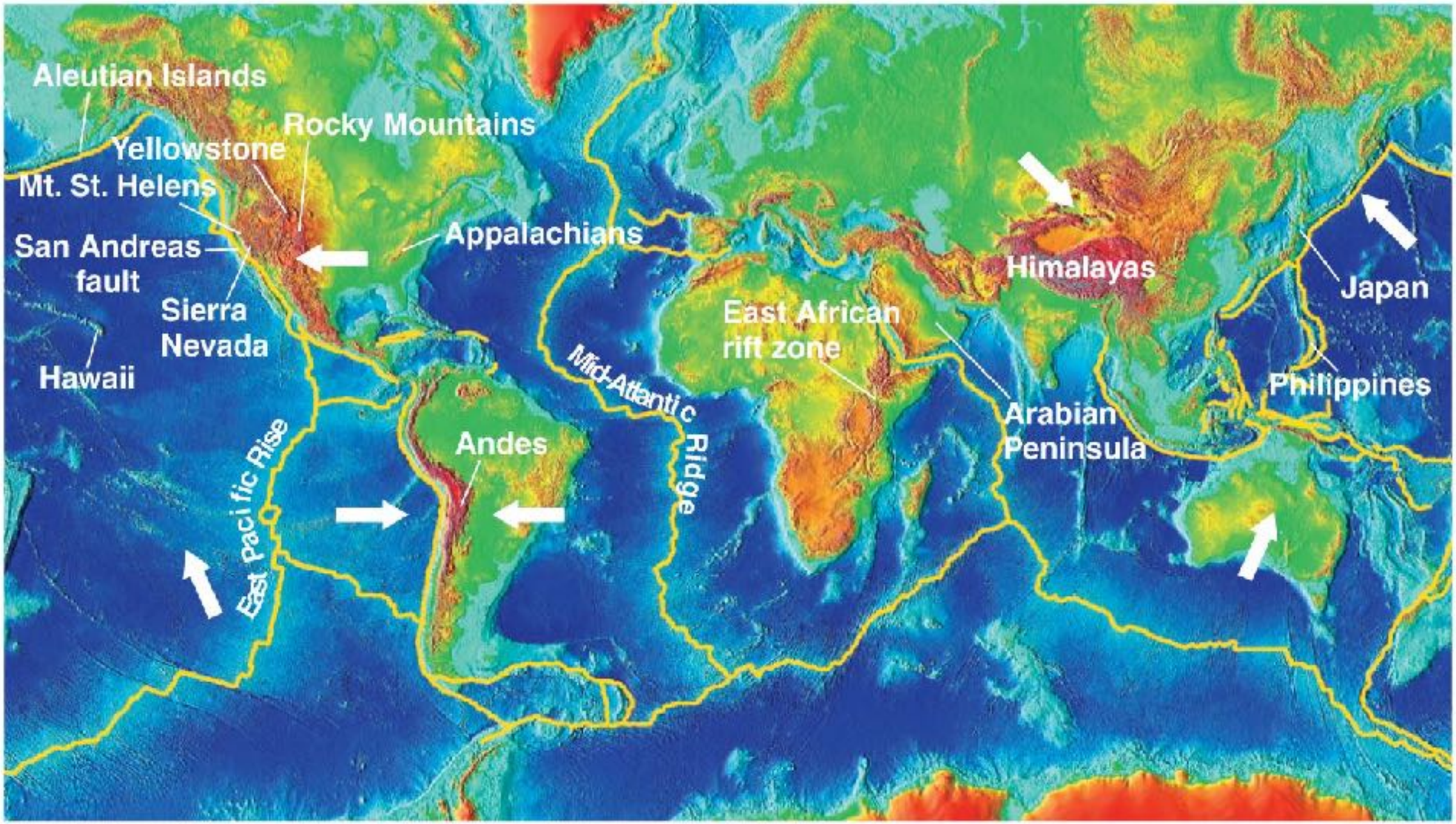
- No flowing water

- Series of Russian landers; lasted from 23 minutes to a couple of hours

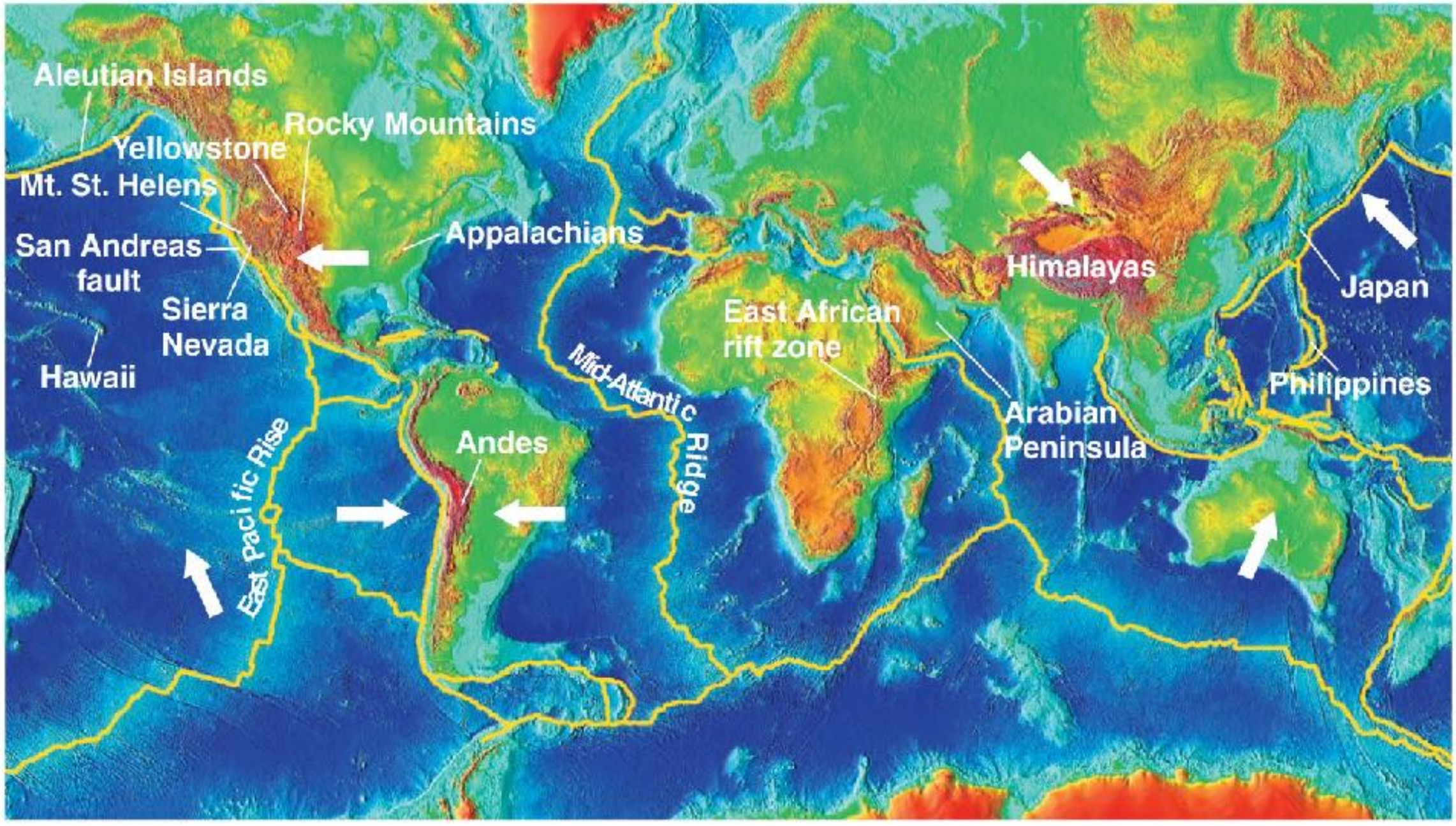
Does Venus have plate tectonics?

- Venus does not appear to have plate tectonics currently, 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

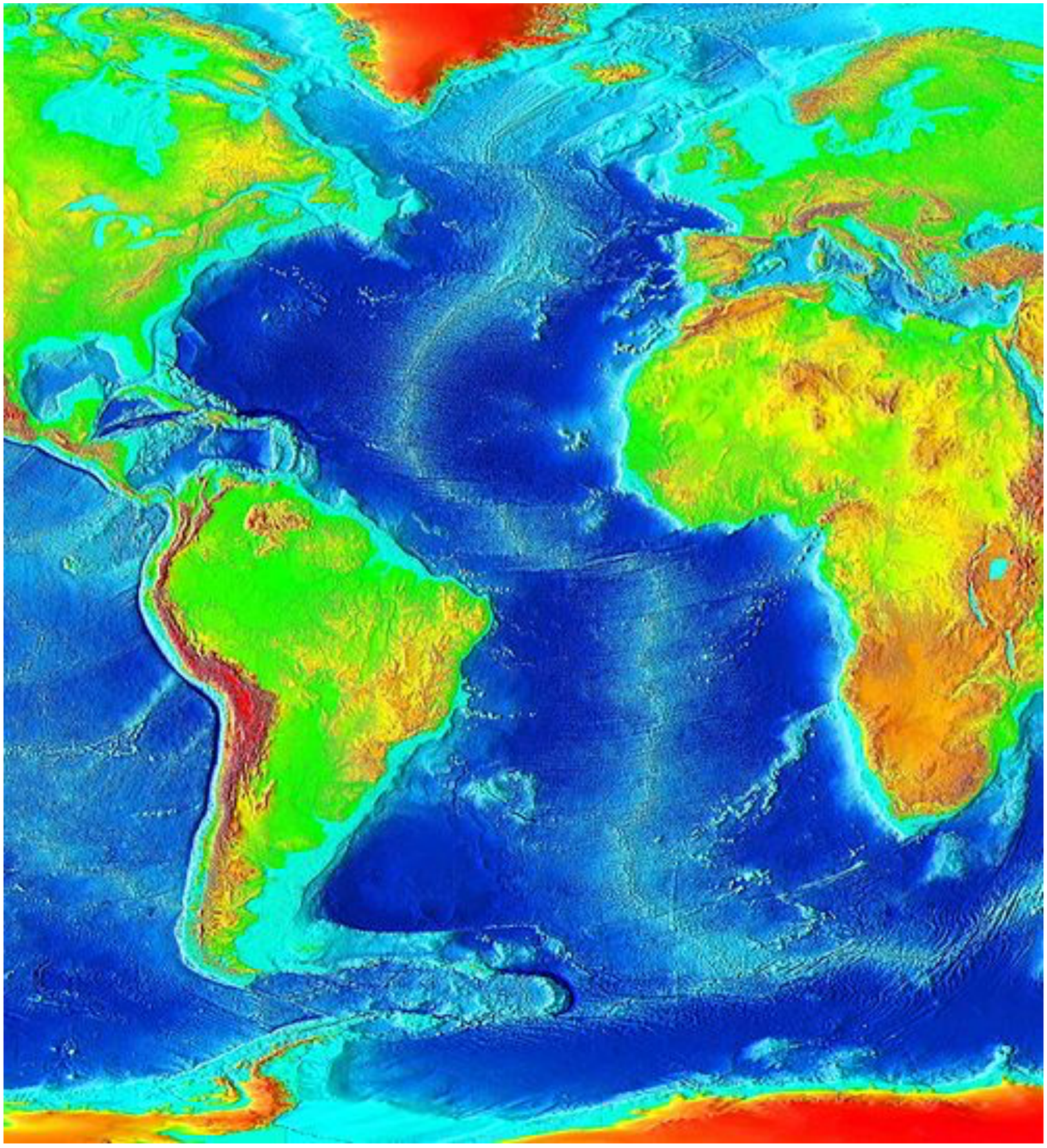


- Motion of the continents can be measured with GPS.

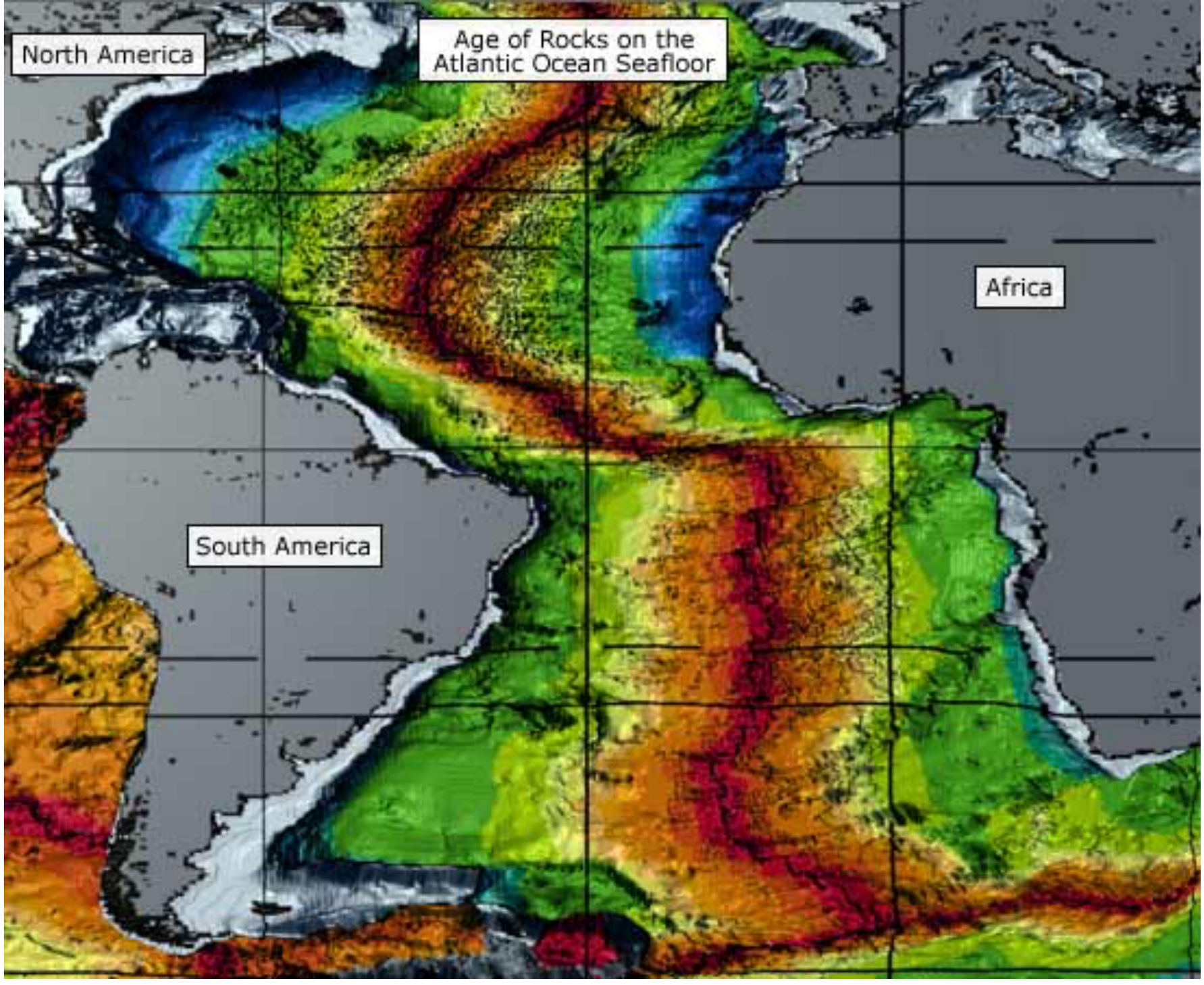
Continental Motion

- The idea of continental drift was inspired by the puzzle-like fit of the continents.

- Mantle material erupts where the seafloor spreads.

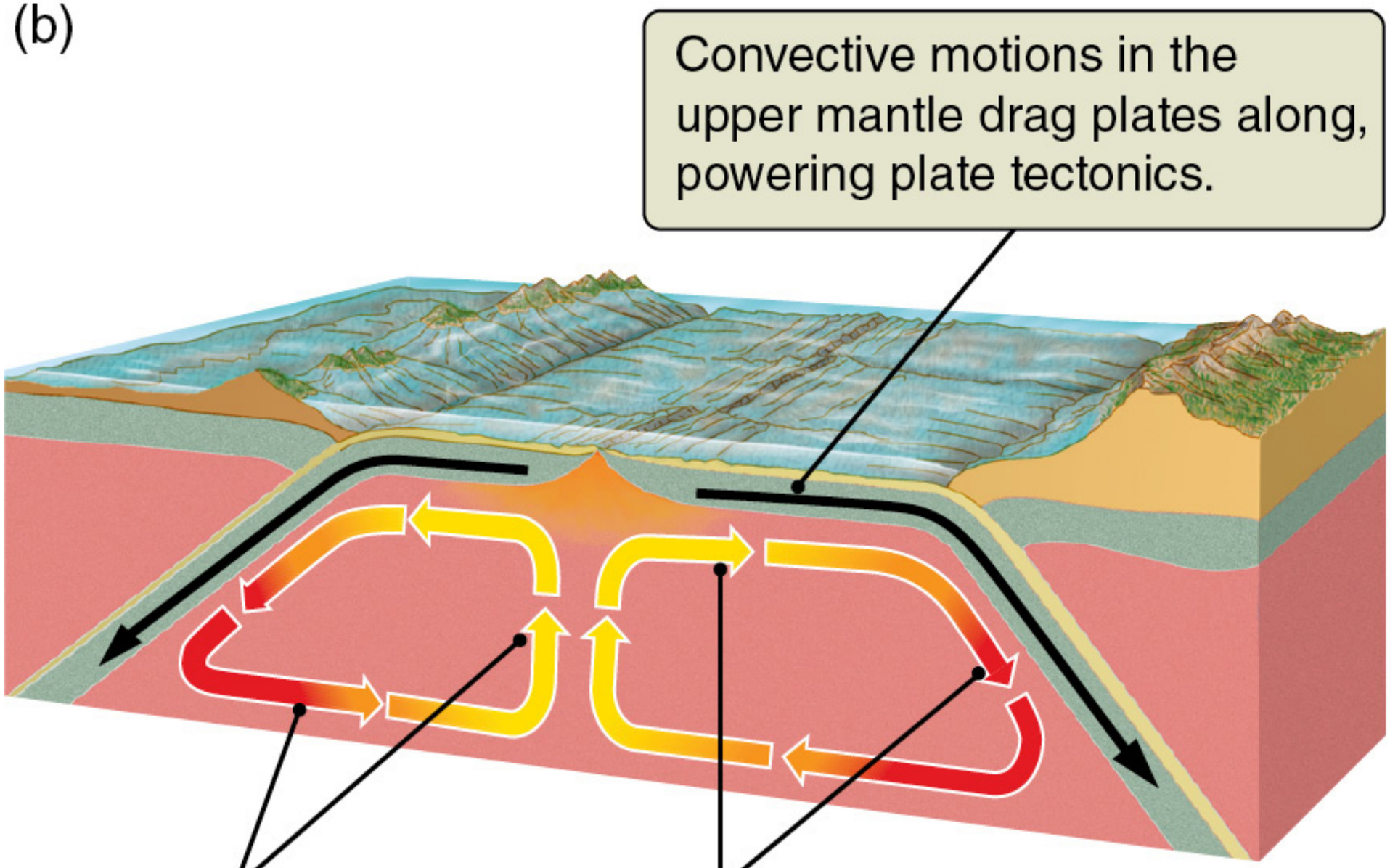


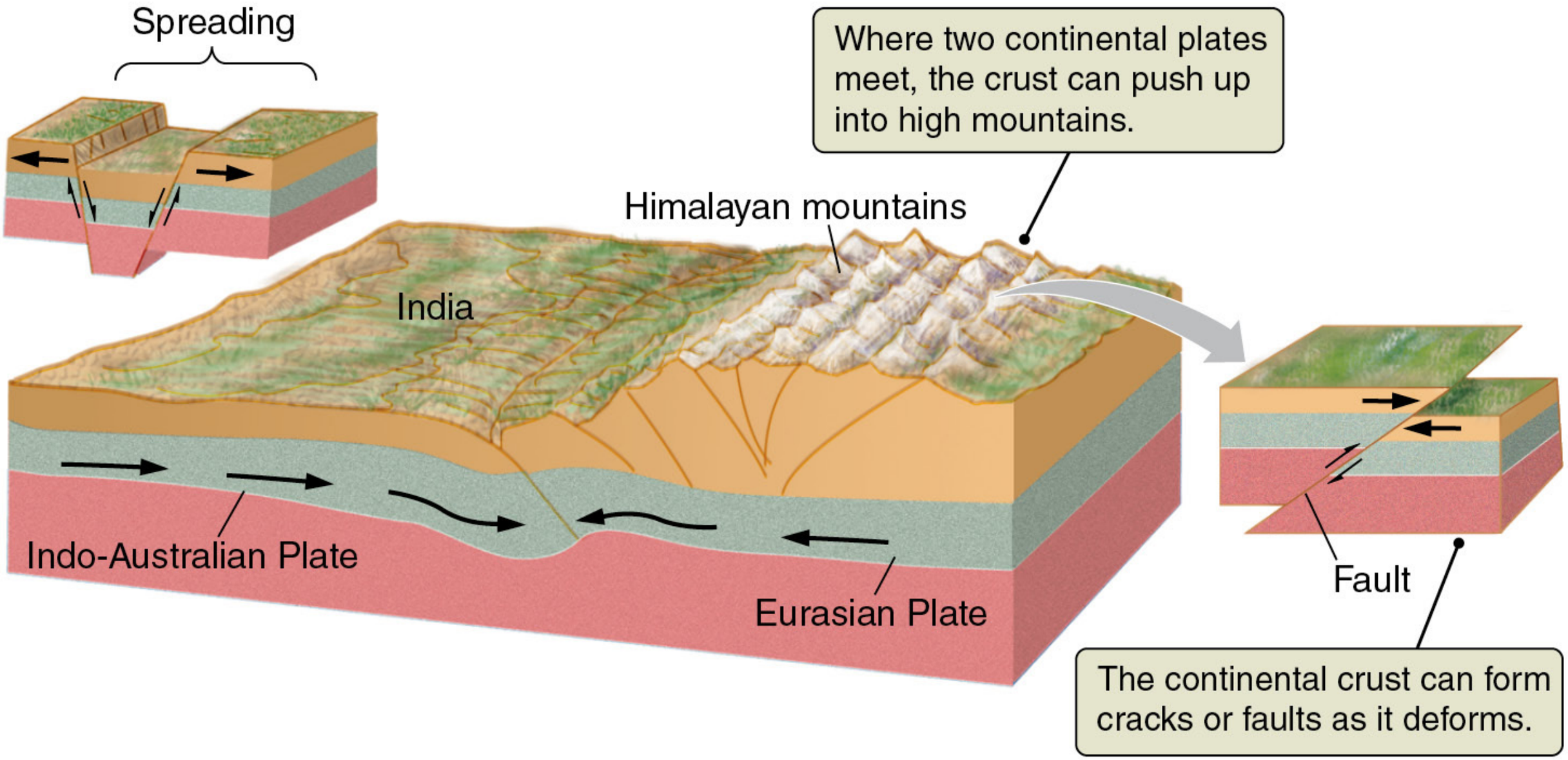
- Mid-Atlantic ridge
- Chain of mountains from whence seafloor spreads
- Age gradient in rocks with youngest at the center of spreading



Younger rocks colored red

(b)

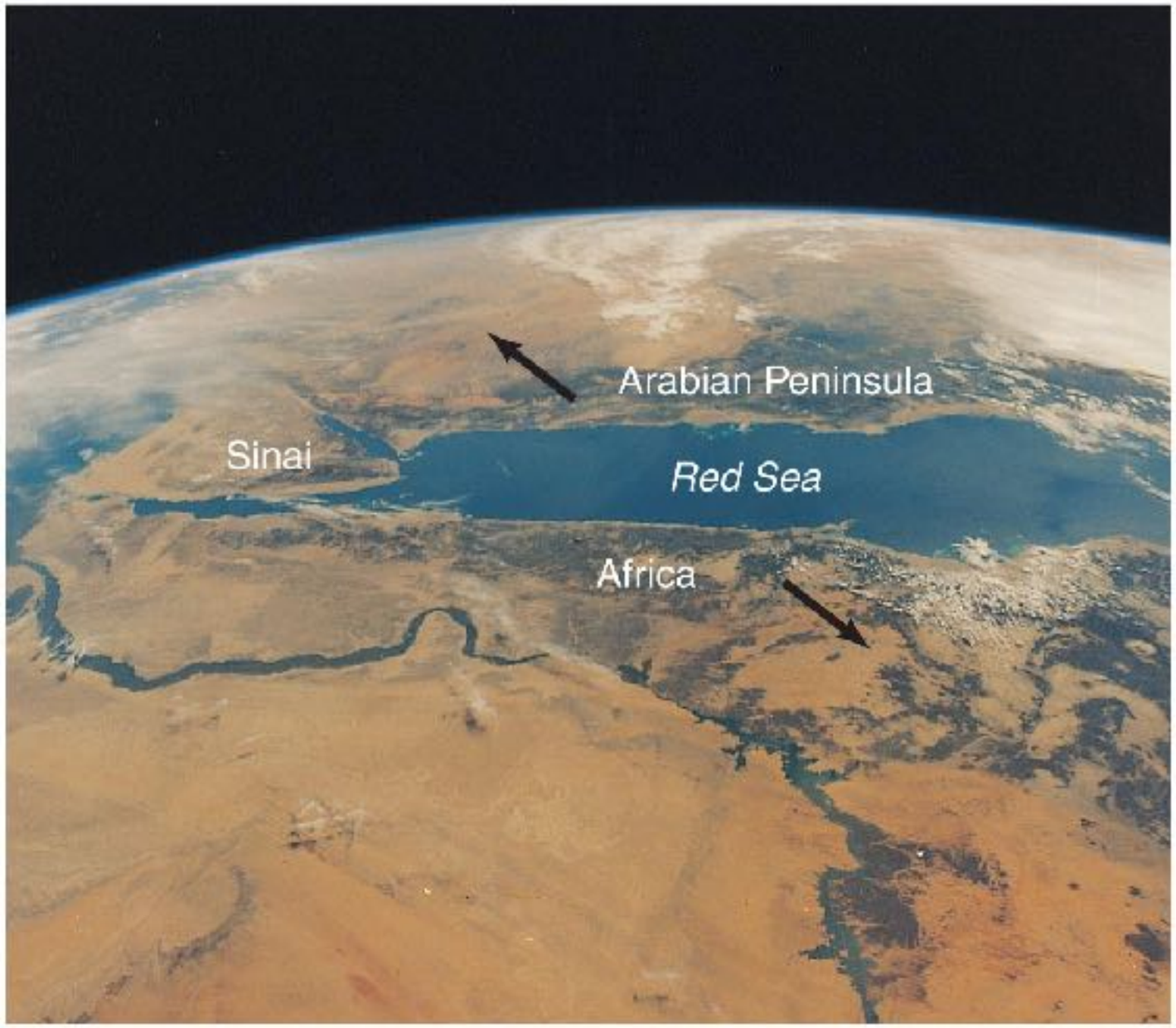

Convective motions in the upper mantle drag plates along, powering plate tectonics.
Mantle is heated from below, becomes buoyant, and rises.
Mantle cools near surface and sinks, displacing hot mantle and pushing it upward.


Spreading
Where two continental plates meet, the crust can push up into high mountains.
Himalayan mountains
India
Indo-Australian Plate
Eurasian Plate
Fault
The continental crust can form cracks or faults as it deforms.

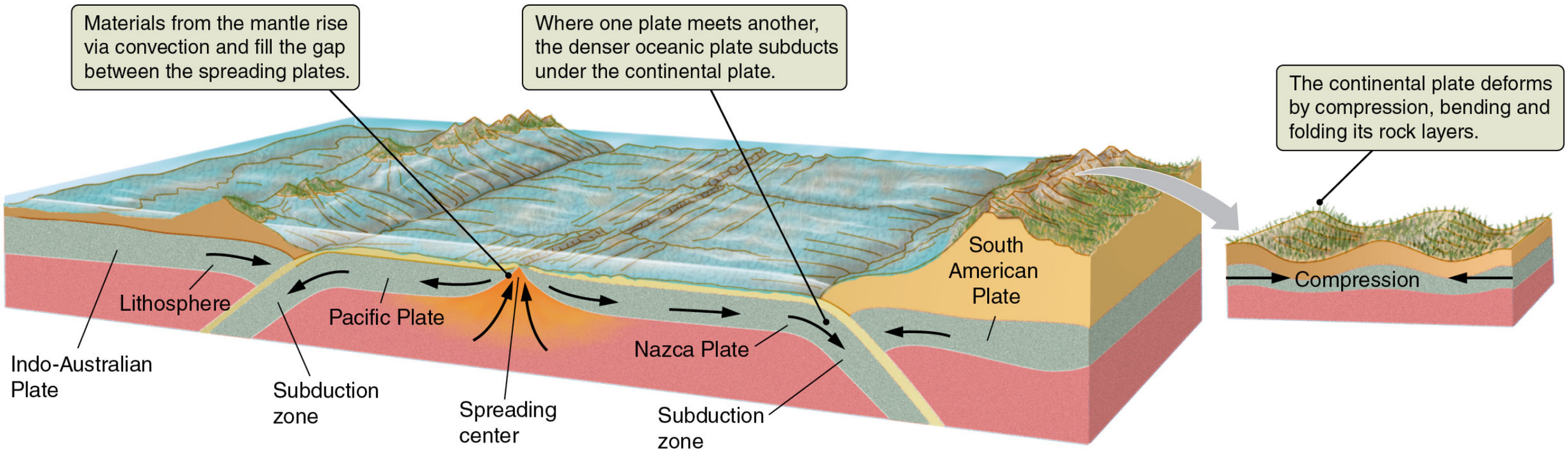
Surface Features

- The Himalayas formed from a collision between plates.

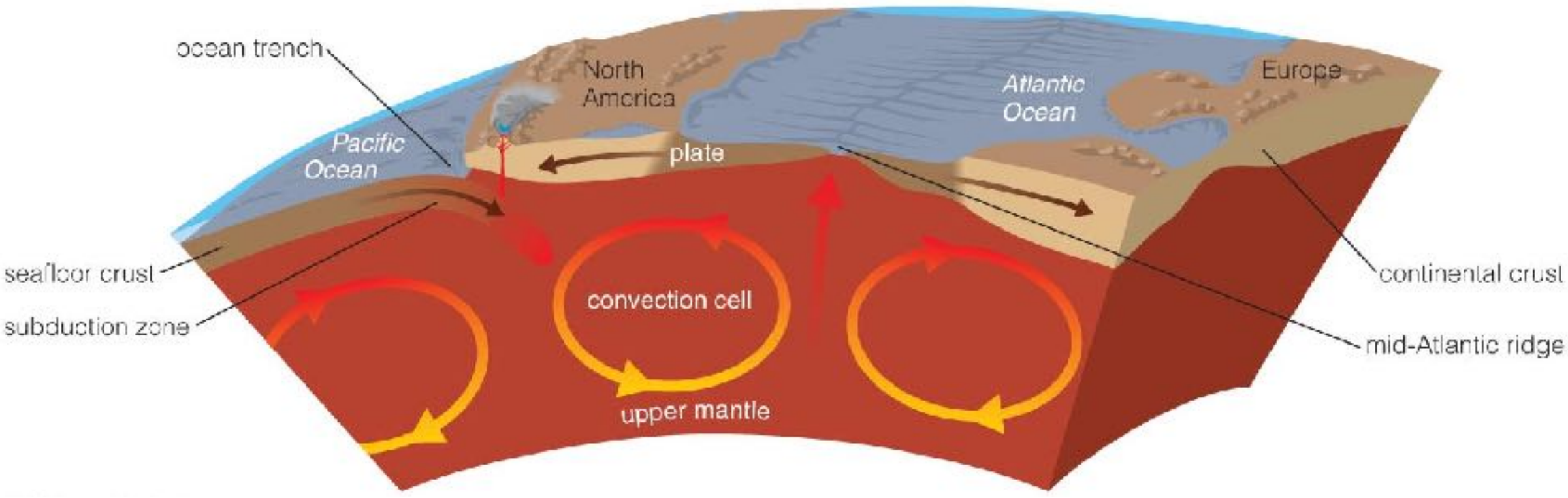
Surface Features



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

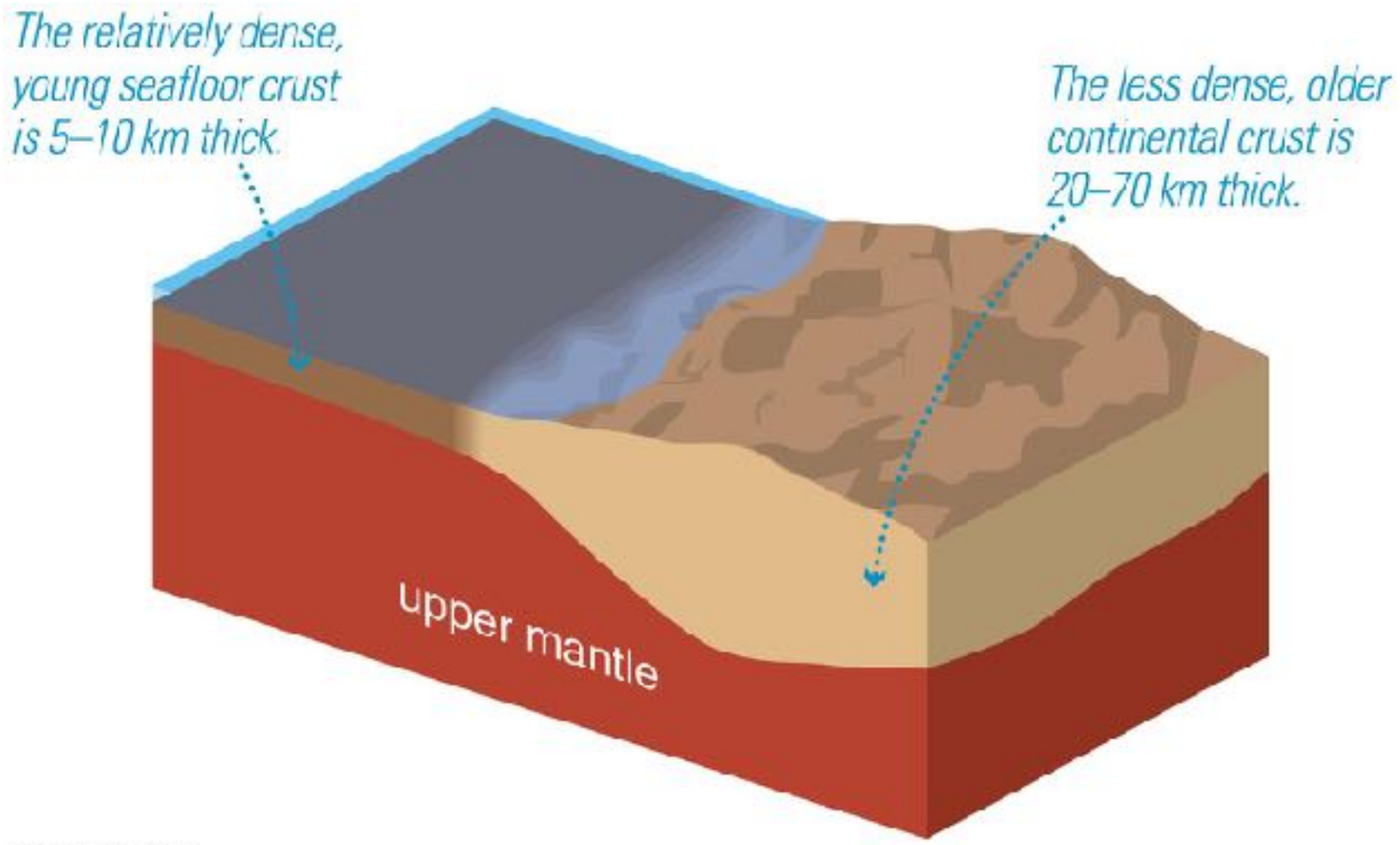

Materials from the mantle rise via convection and fill the gap between the spreading plates.
Where one plate meets another, the denser oceanic plate subducts under the continental plate.
The continental plate deforms by compression, bending and folding its rock layers.
South American Plate
Lithosphere
Pacific Plate
Indo-Australian Plate
Subduction zone
Spreading center
Nazca Plate
Subduction zone
Compression

Seafloor Recycling



- Seafloor is recycled through a process known as subduction.

Seafloor Crust



- Thin seafloor crust differs from thick continental crust.
- Dating of the seafloor shows that it is usually young (by geological standards).

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

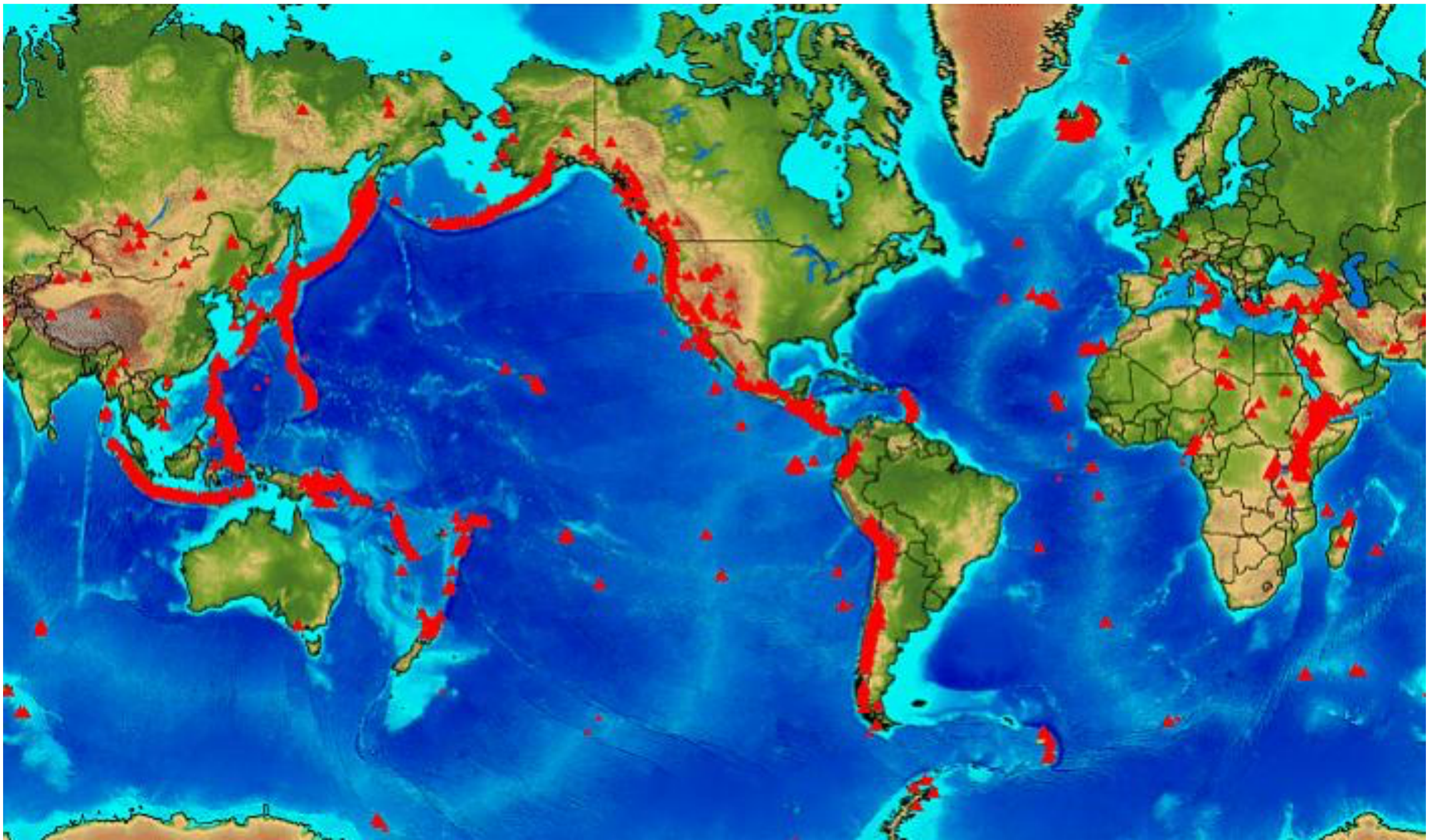
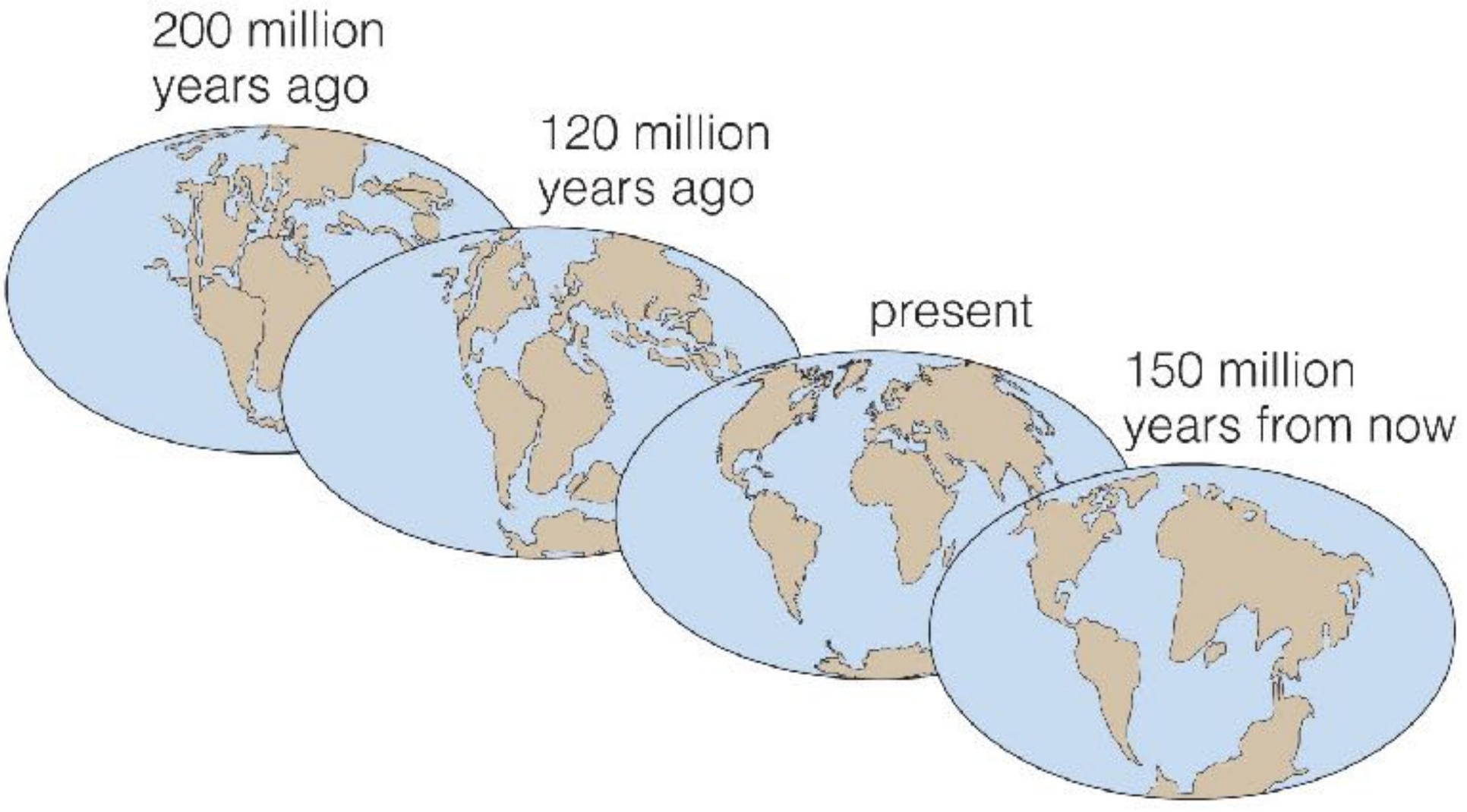


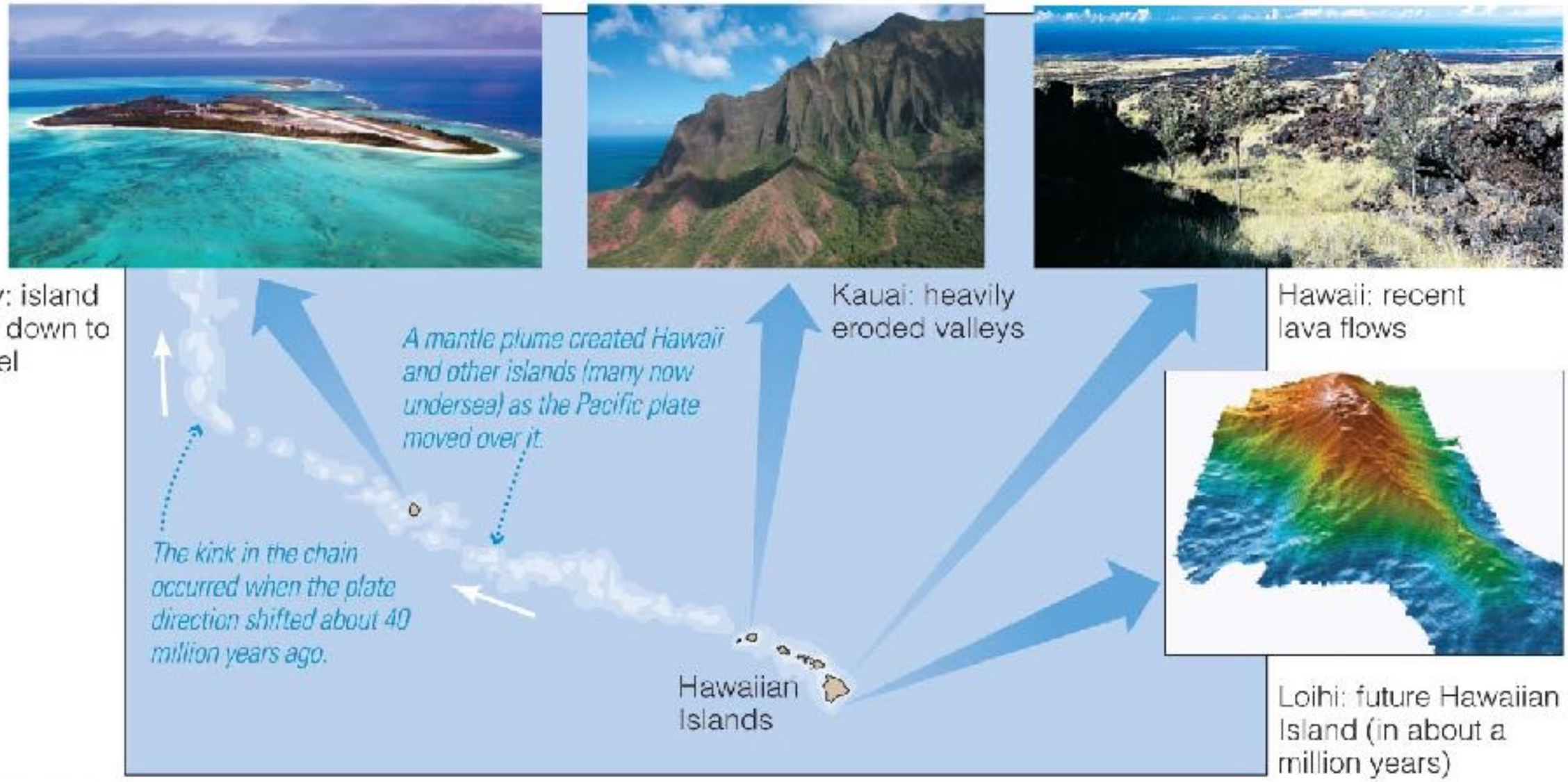
Plate Motions

- 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

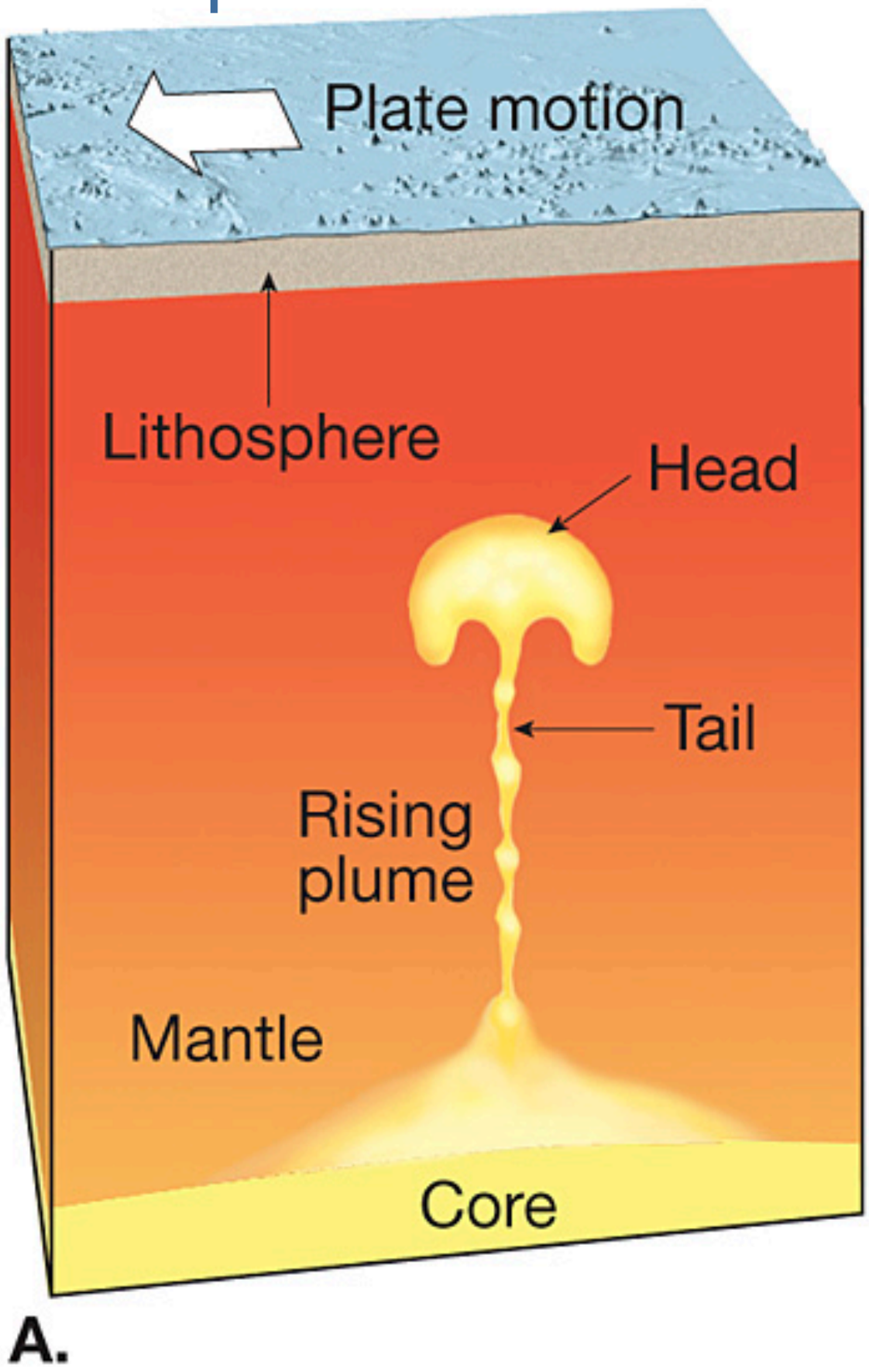
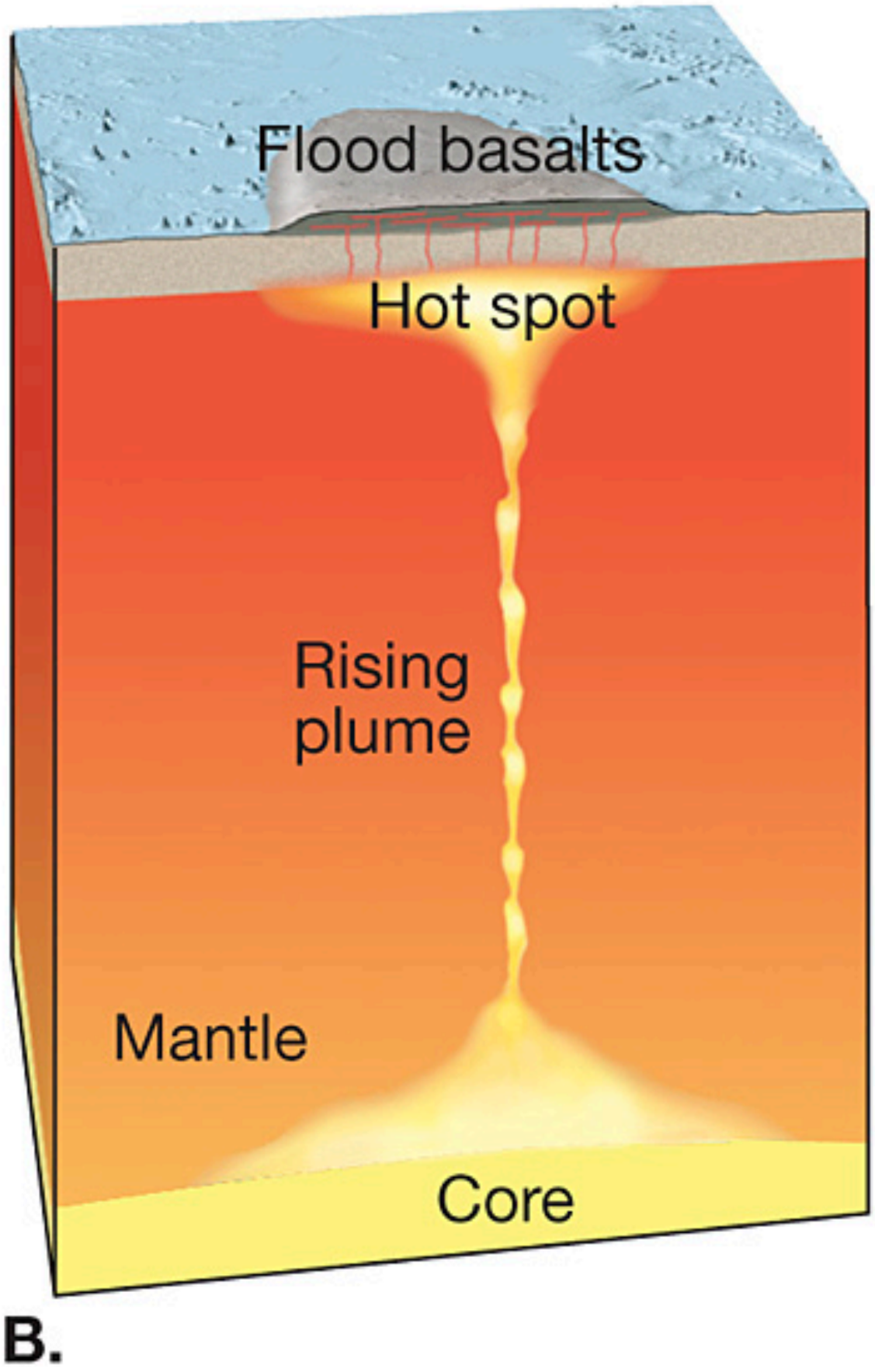


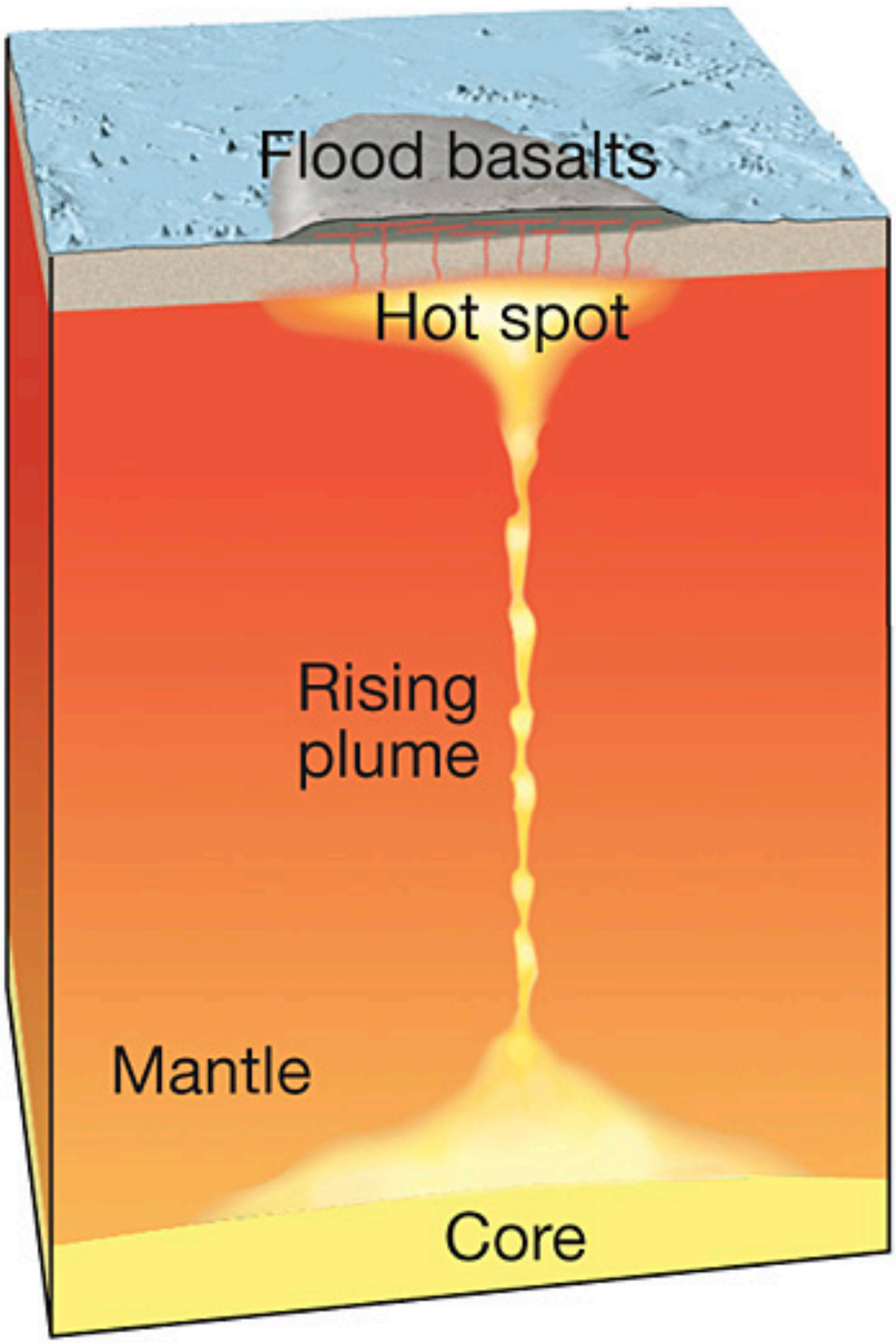
Plate motion
Lithosphere
Head
Tail
Rising plume
Mantle
Core

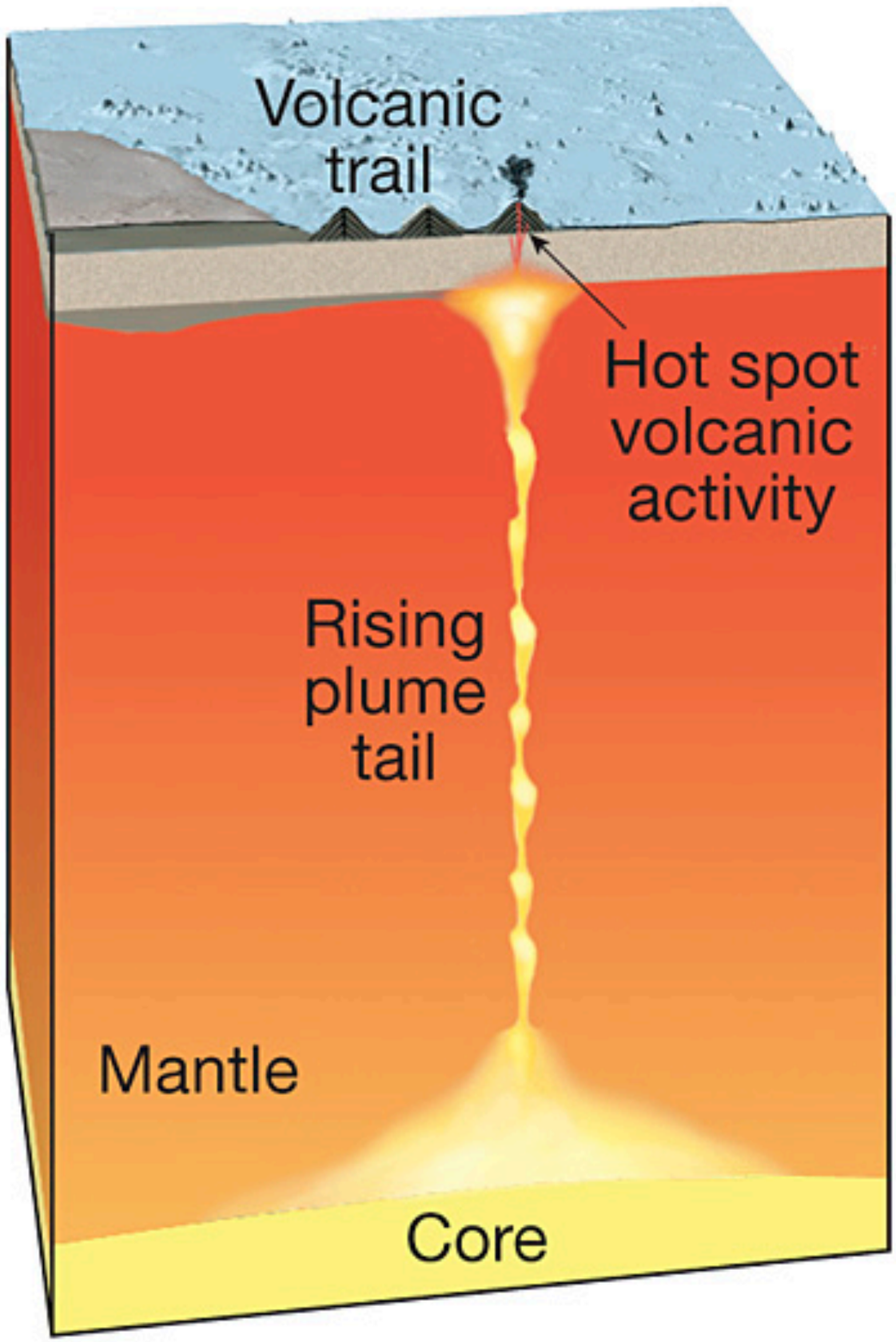
A.

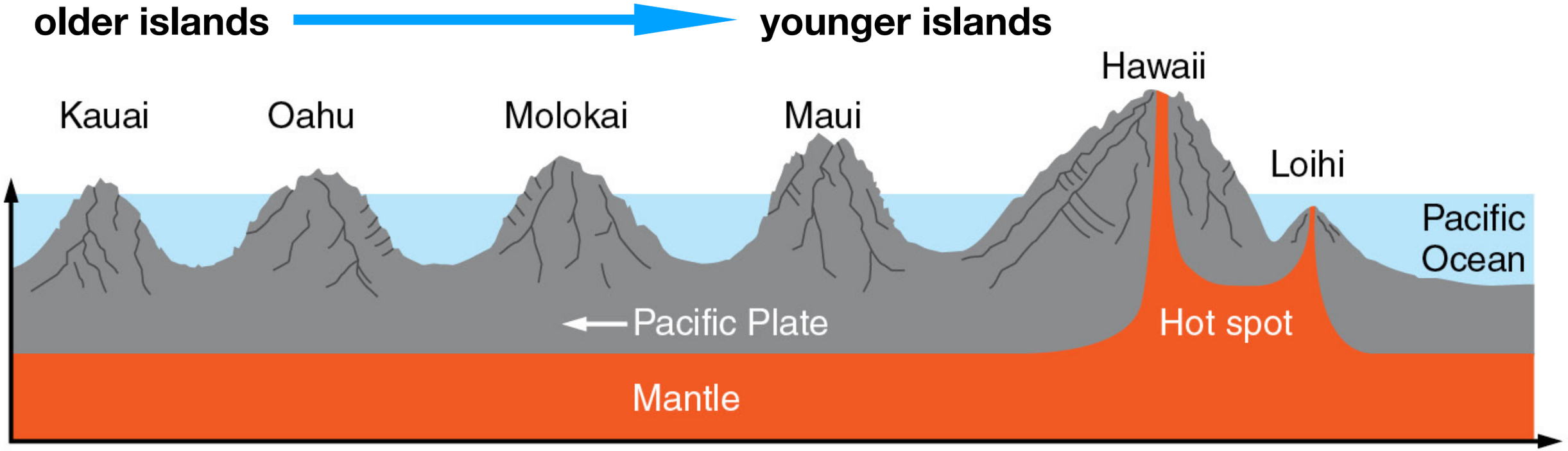

Flood basalts
Hot spot
Rising plume
Mantle
Core

B.

Hot Spots

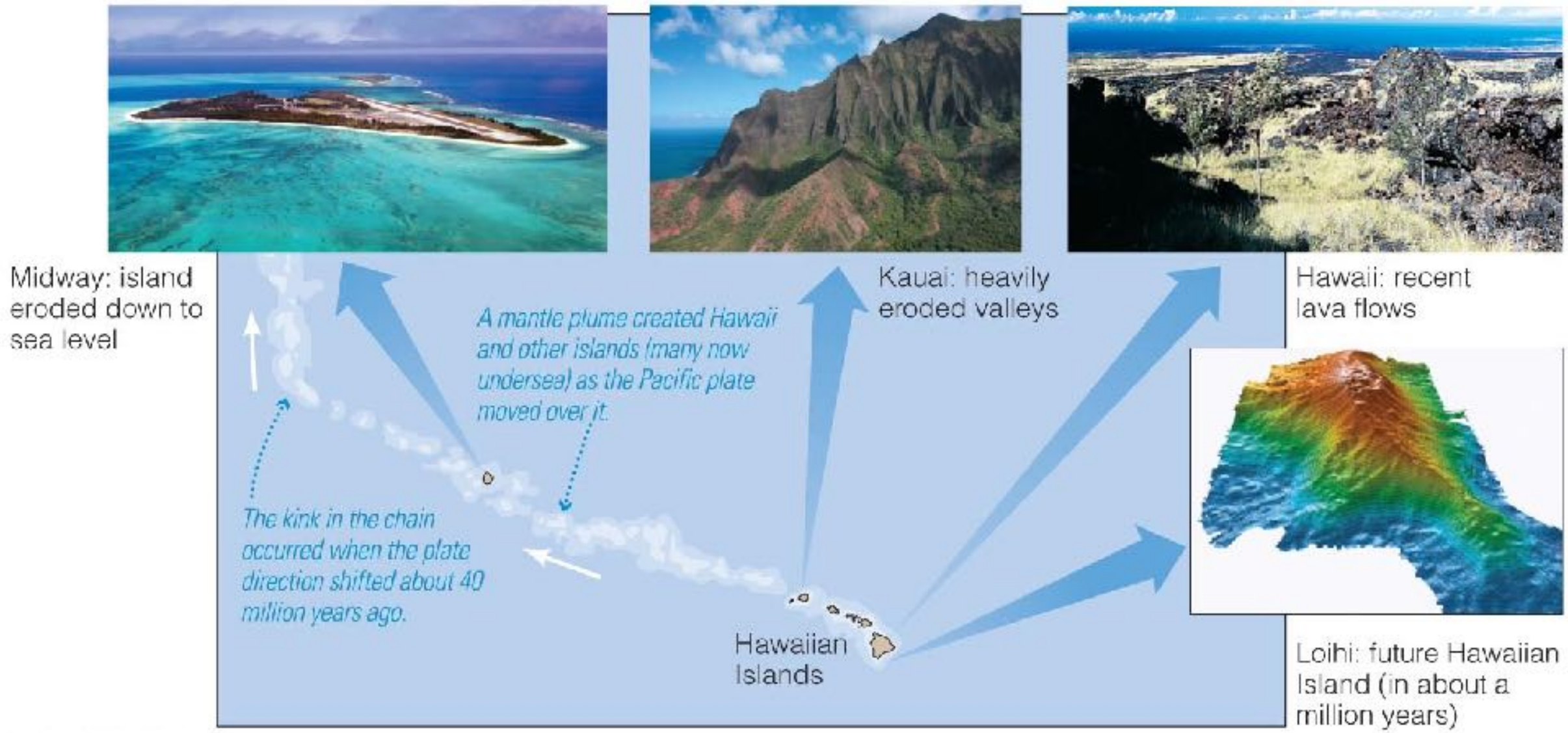

Flood basalts
Hot spot
Rising plume
Mantle
Core


Volcanic trail
Hot spot volcanic activity
Rising plume tail
Mantle
Core


older islands
younger islands
Kauai
Oahu
Molokai
Maui
Hawaii
Loihi
Pacific Ocean
Pacific Plate
Hot spot
Mantle

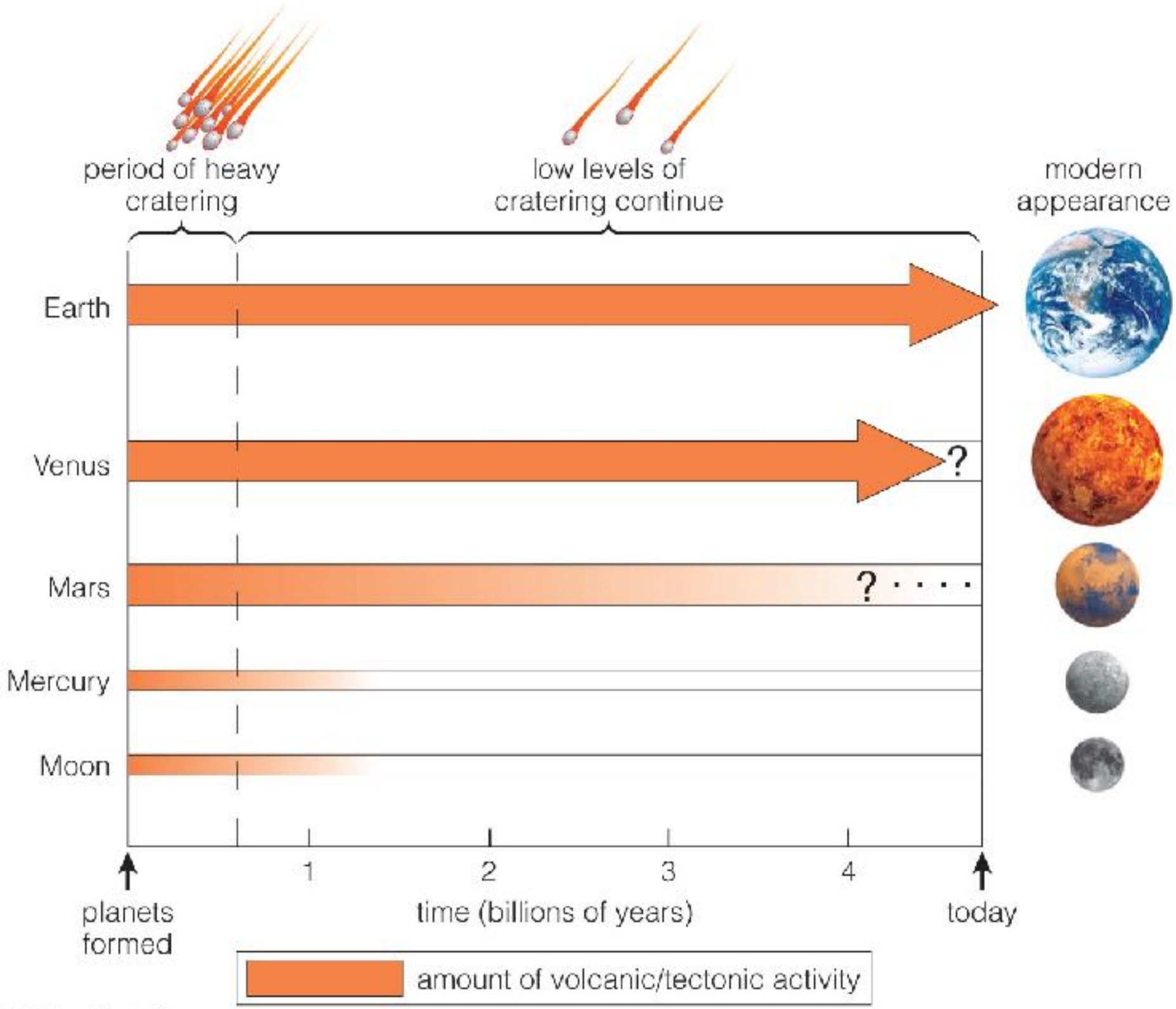
Hot Spots

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

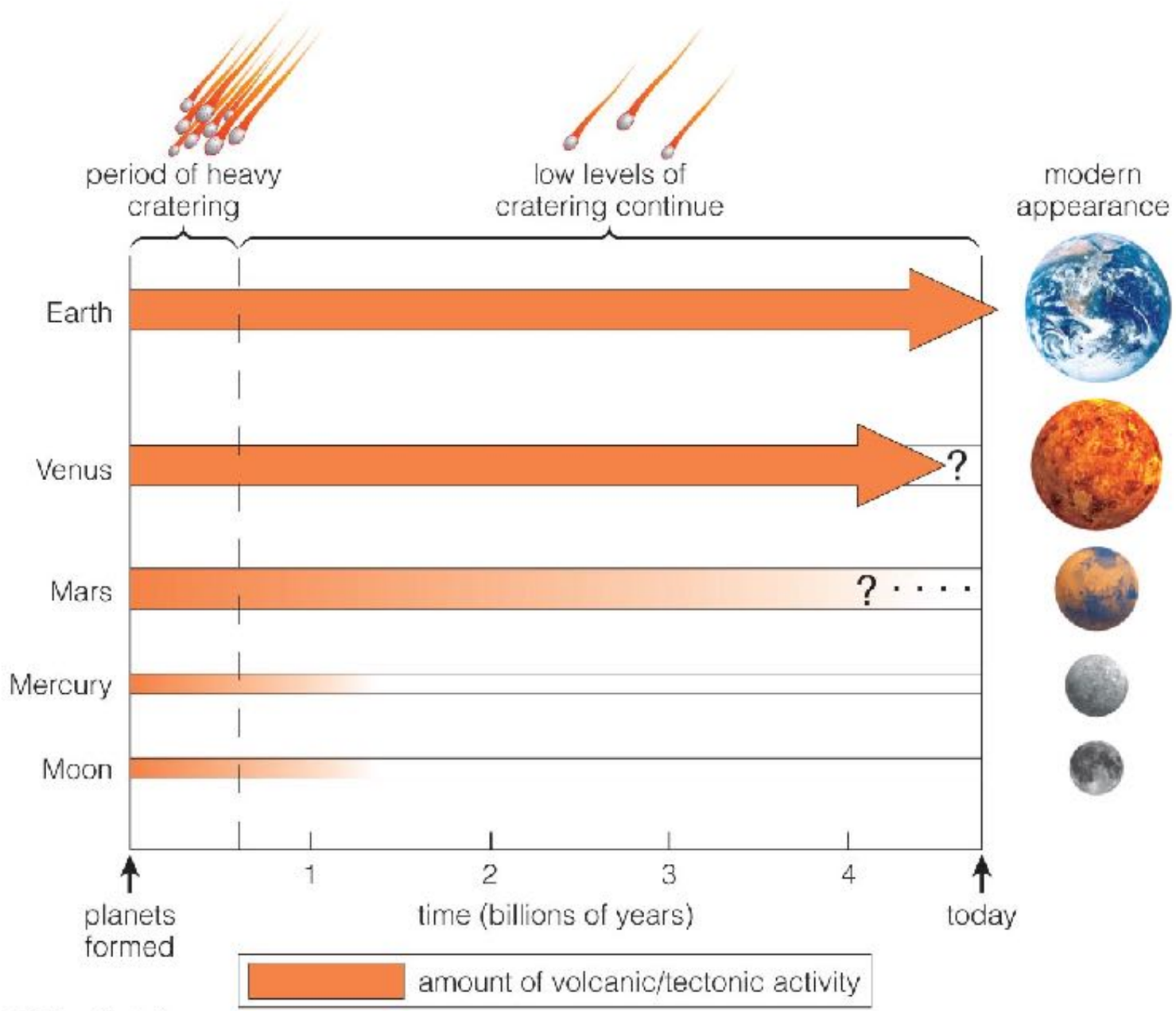


- The Hawaiian islands have formed where a plate is moving over a volcanic hot spot.

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?

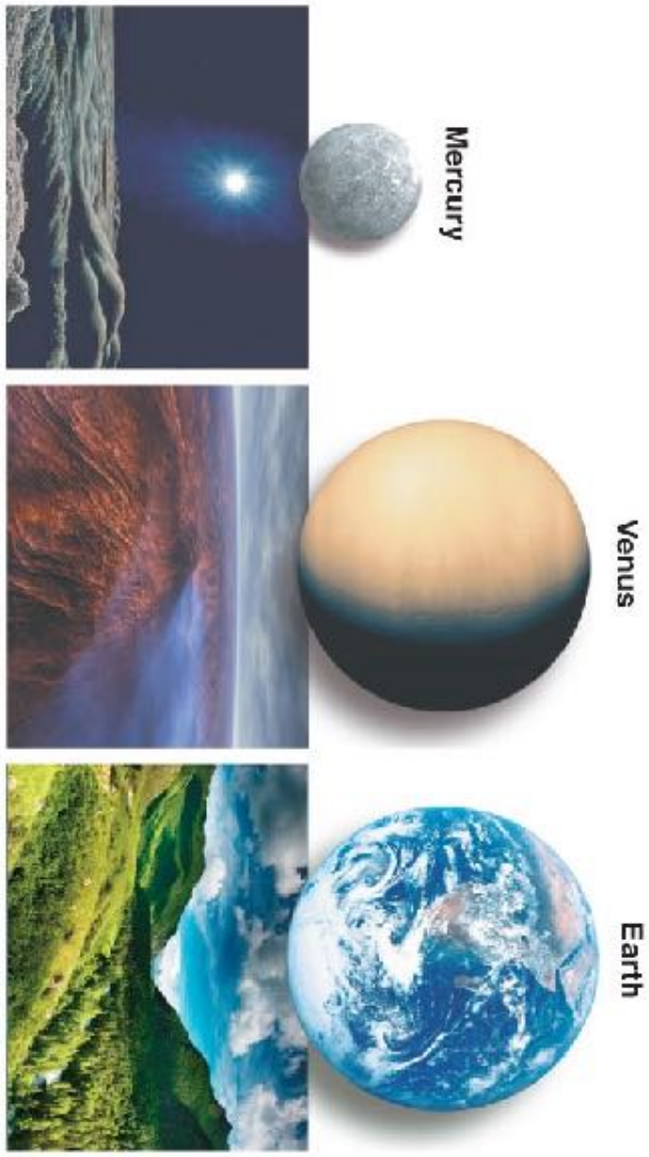
- How is Earth's surface shaped by plate tectonics?
  - Measurements of plate motions confirm the idea of continental drift.
  - Plate tectonics is responsible for subduction, seafloor spreading, mountains, rifts, and earthquakes.

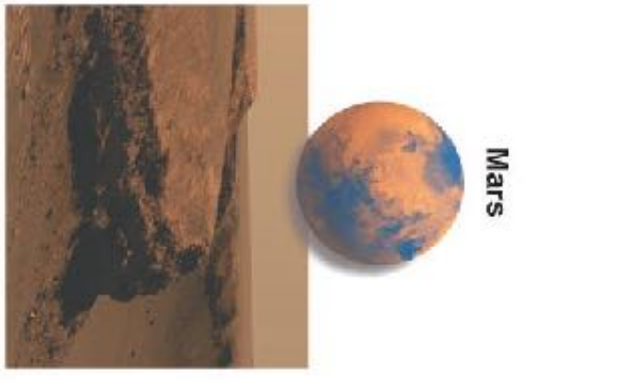
What have we learned?

- 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.

What is an atmosphere?

- An atmosphere is a layer of gas that surrounds a planet.
  - Terrestrial planet atmospheres are a very thin veil of gas between the solid surface and the vacuum of space





	Composition	Pressure	Temperature
Mercury	N/A	0	797 (day) -283 (night)
Venus	96% CO_2 3.5% N_2 <1% SO_2	90 (equivalent to 900m deep in the ocean)	878
Earth	78% N_2 21% O_2 <1% H_2O, CO_2	1	59 (global ave)
Moon	N/A	0	257 -283
Mars	95% CO_2 2.7% N_2	0.007	-58
		Earth Atm	Farenheit