

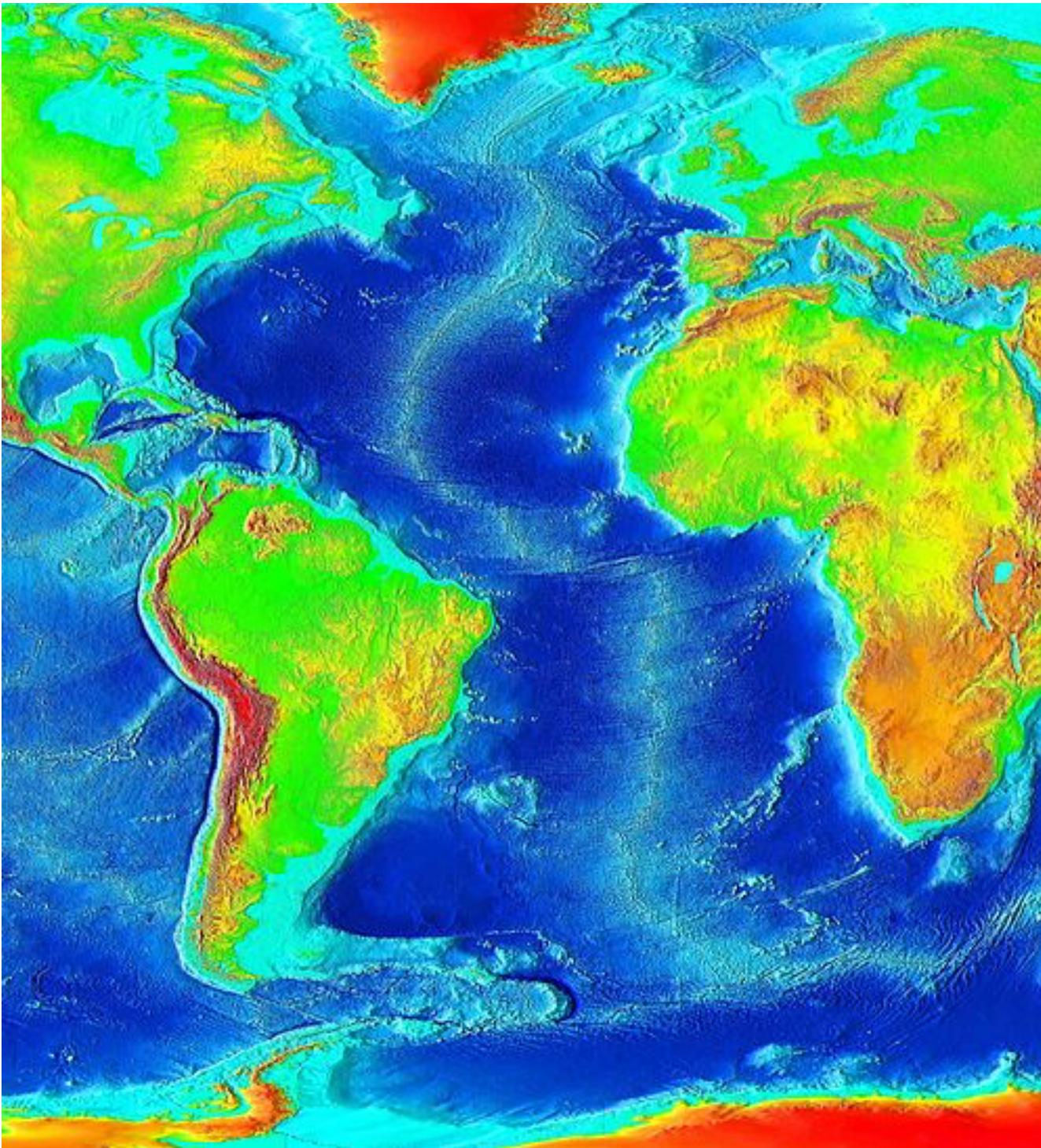


# Today

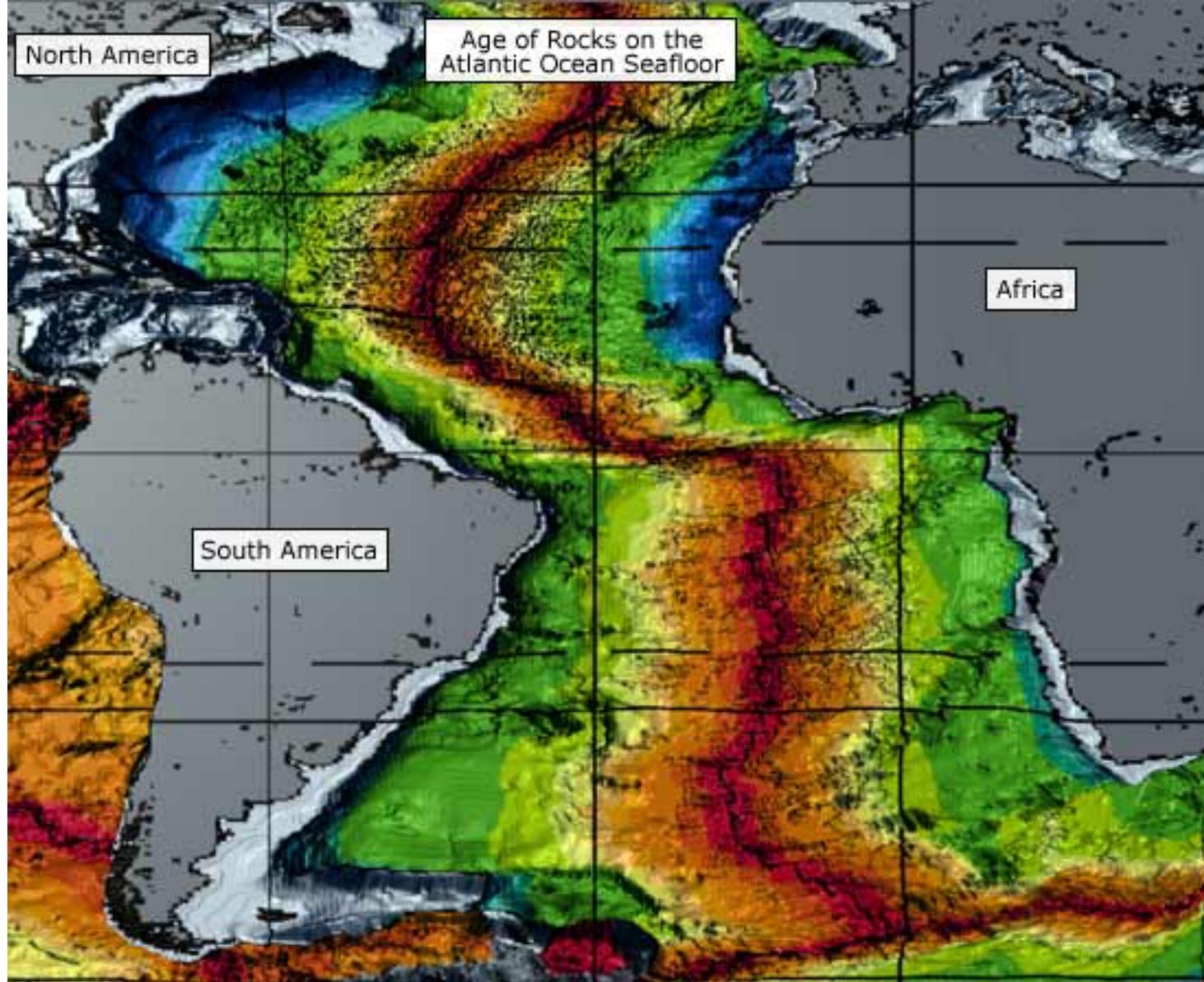
- Terrestrial Planet Atmospheres
- General
- but first - a little more geology

# Events

- Homework DUE next time



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

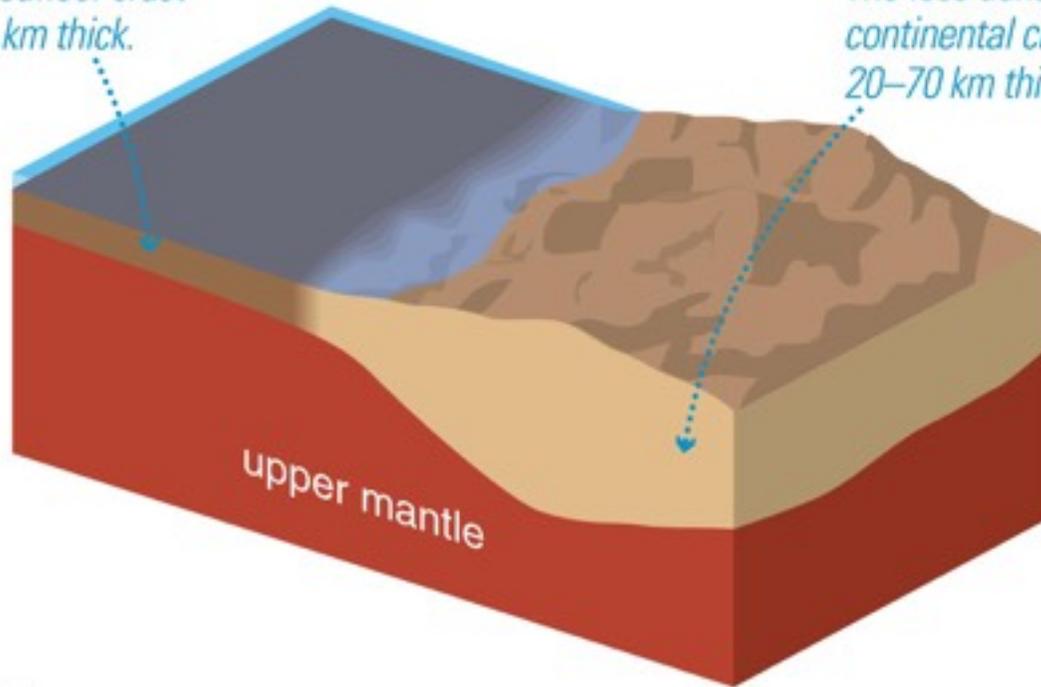


Younger rocks colored red

# Seafloor Crust

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

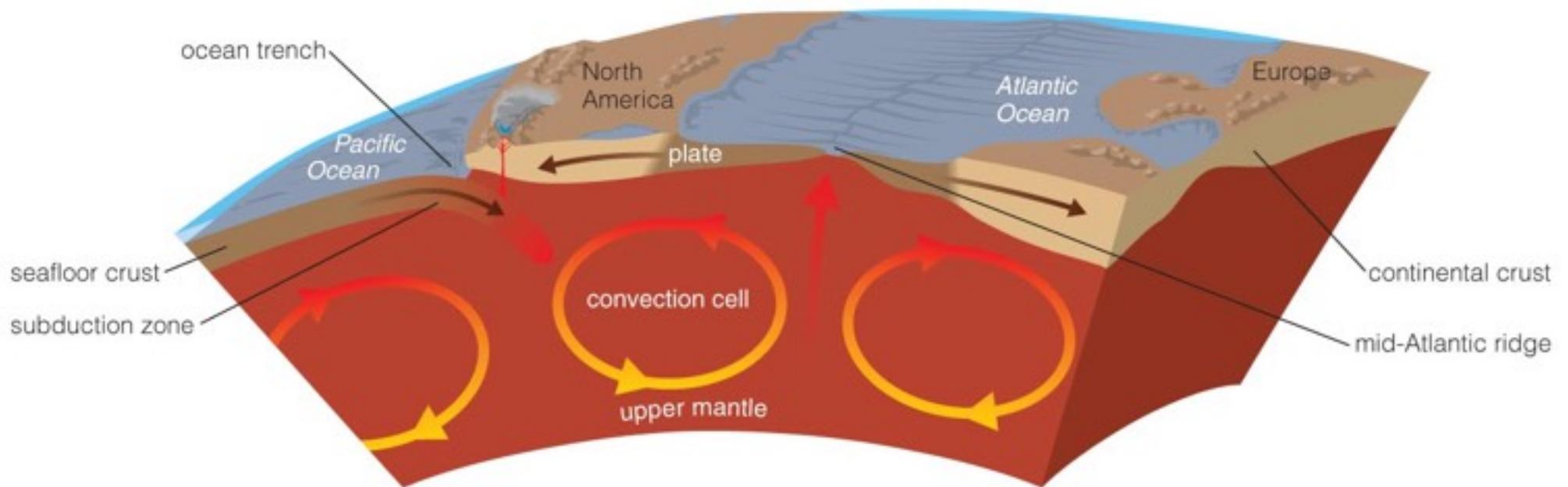
*The less dense, older continental crust is 20–70 km thick.*



- 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



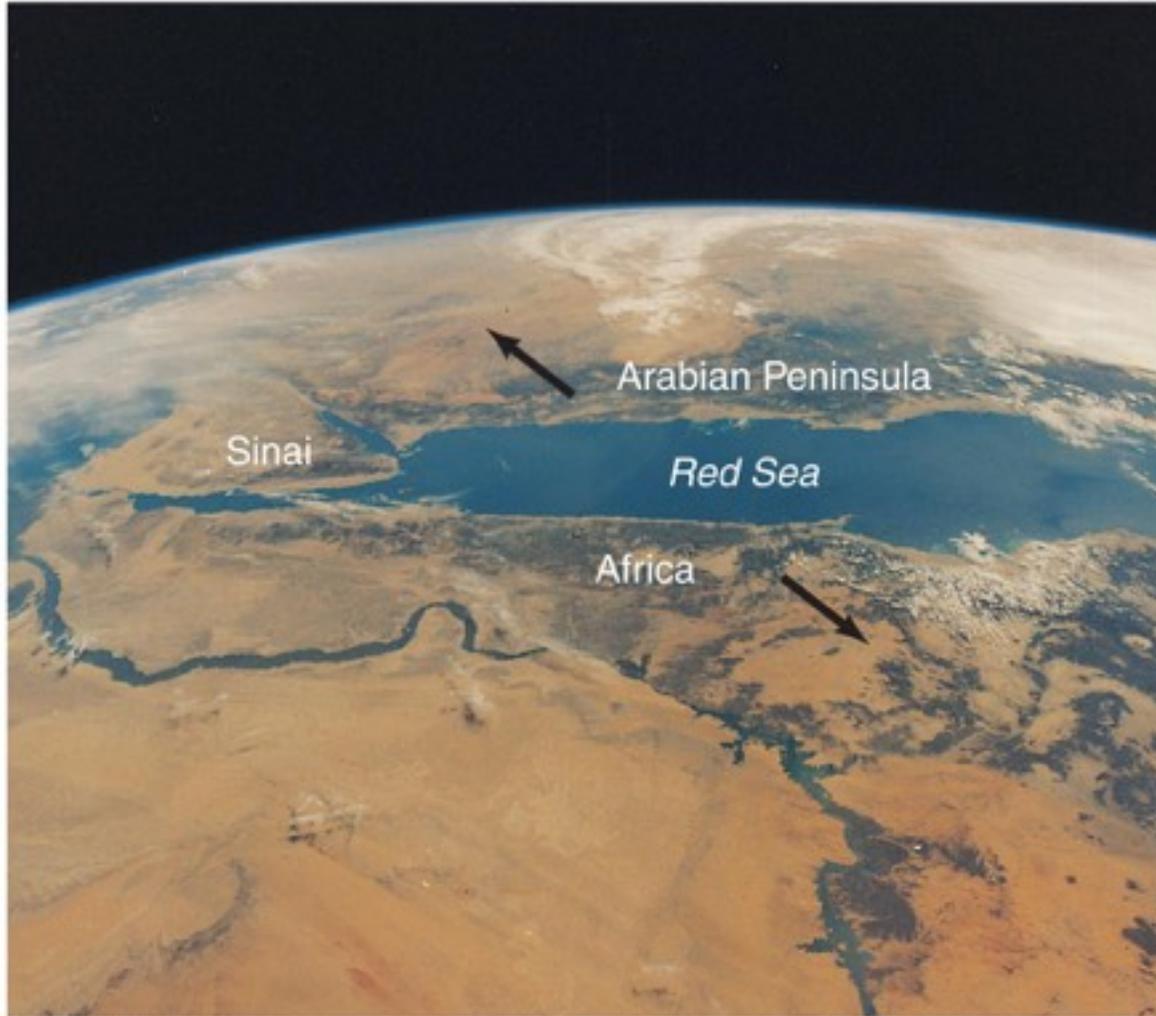
- Major geological features of North America record the history of plate tectonics.

# Surface Features



- The Himalayas formed from a collision between plates.

# Surface Features



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

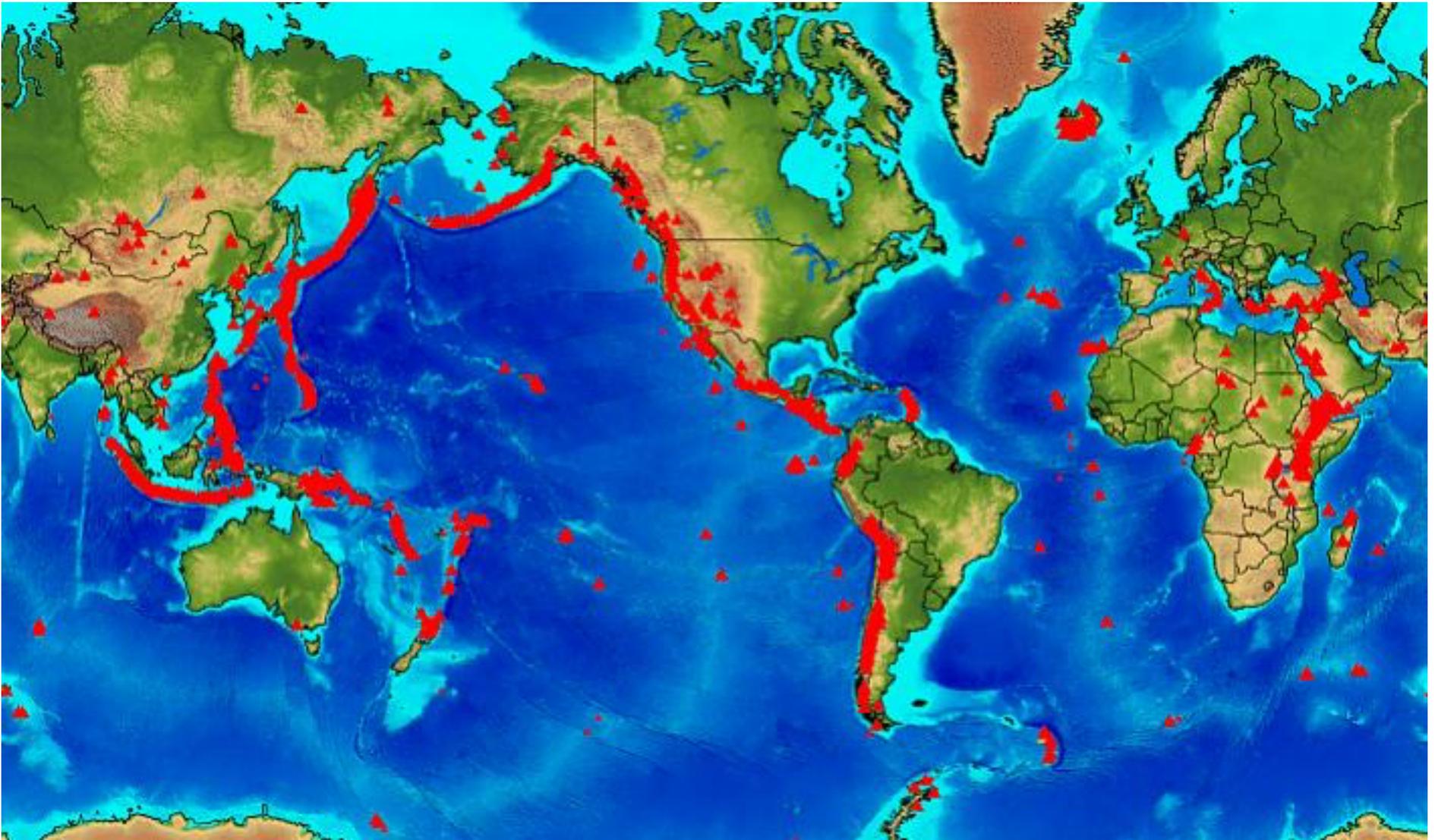
# Rifts, Faults, Earthquakes



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

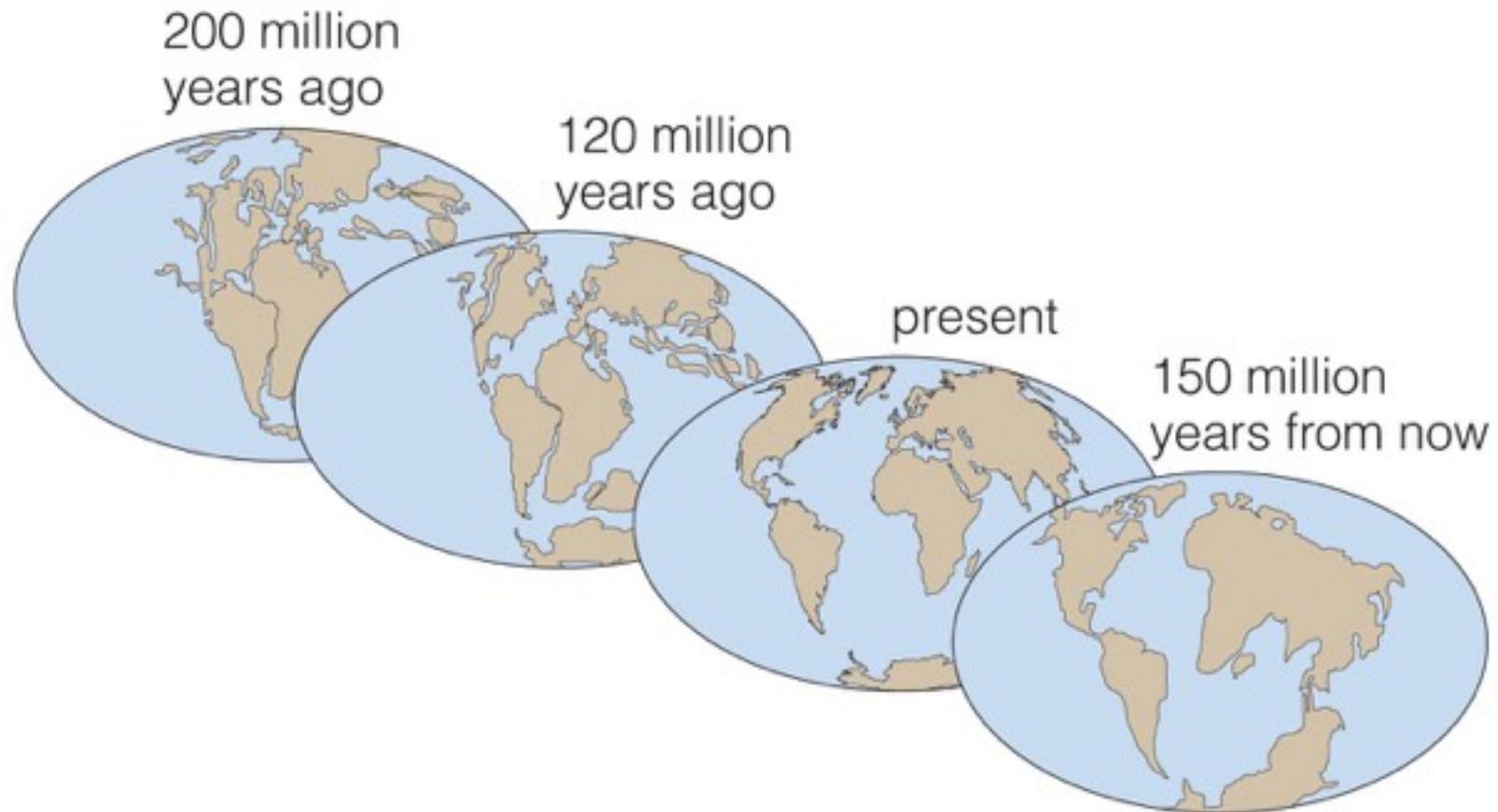
# Ring of Fire

- Boundaries of plates traced by Earthquakes and Volcanos



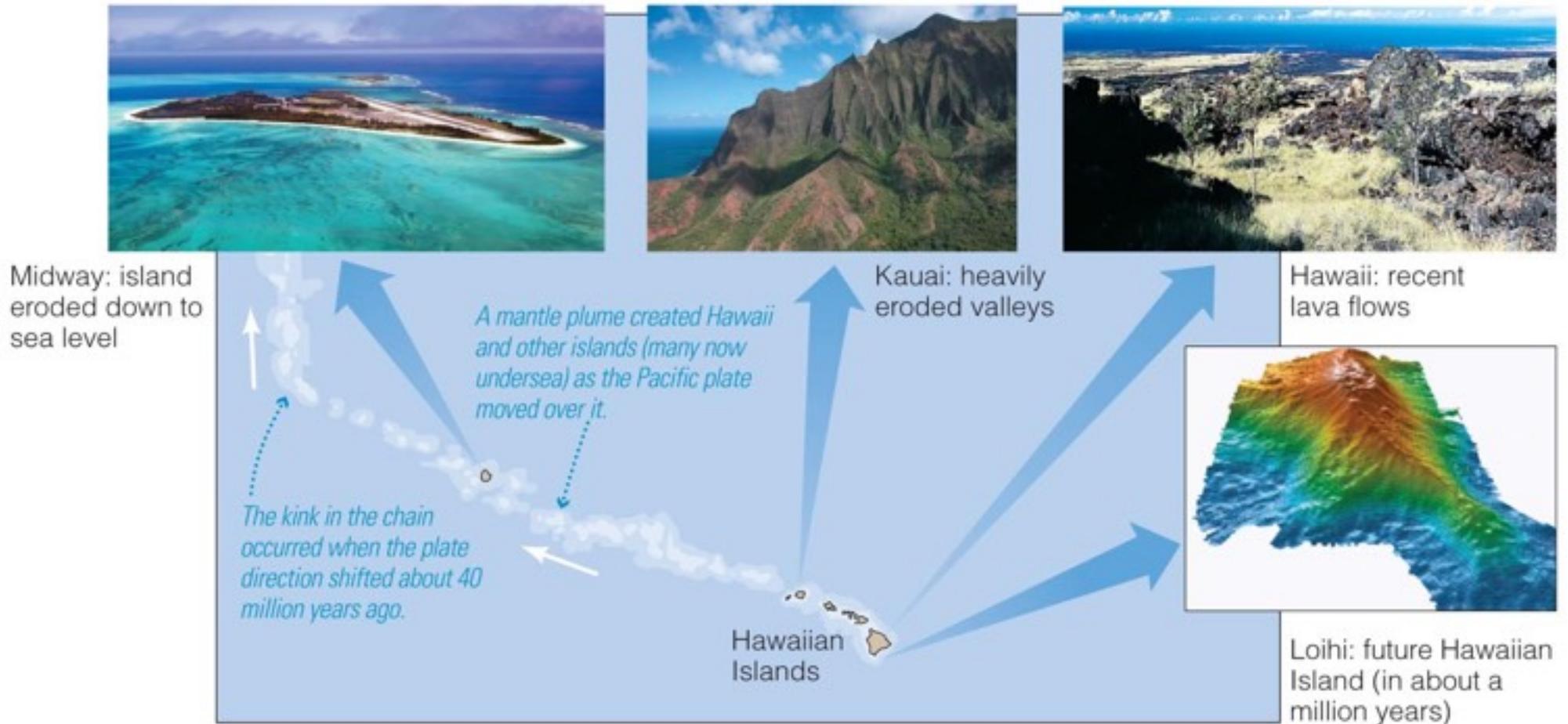
# Plate Motions

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



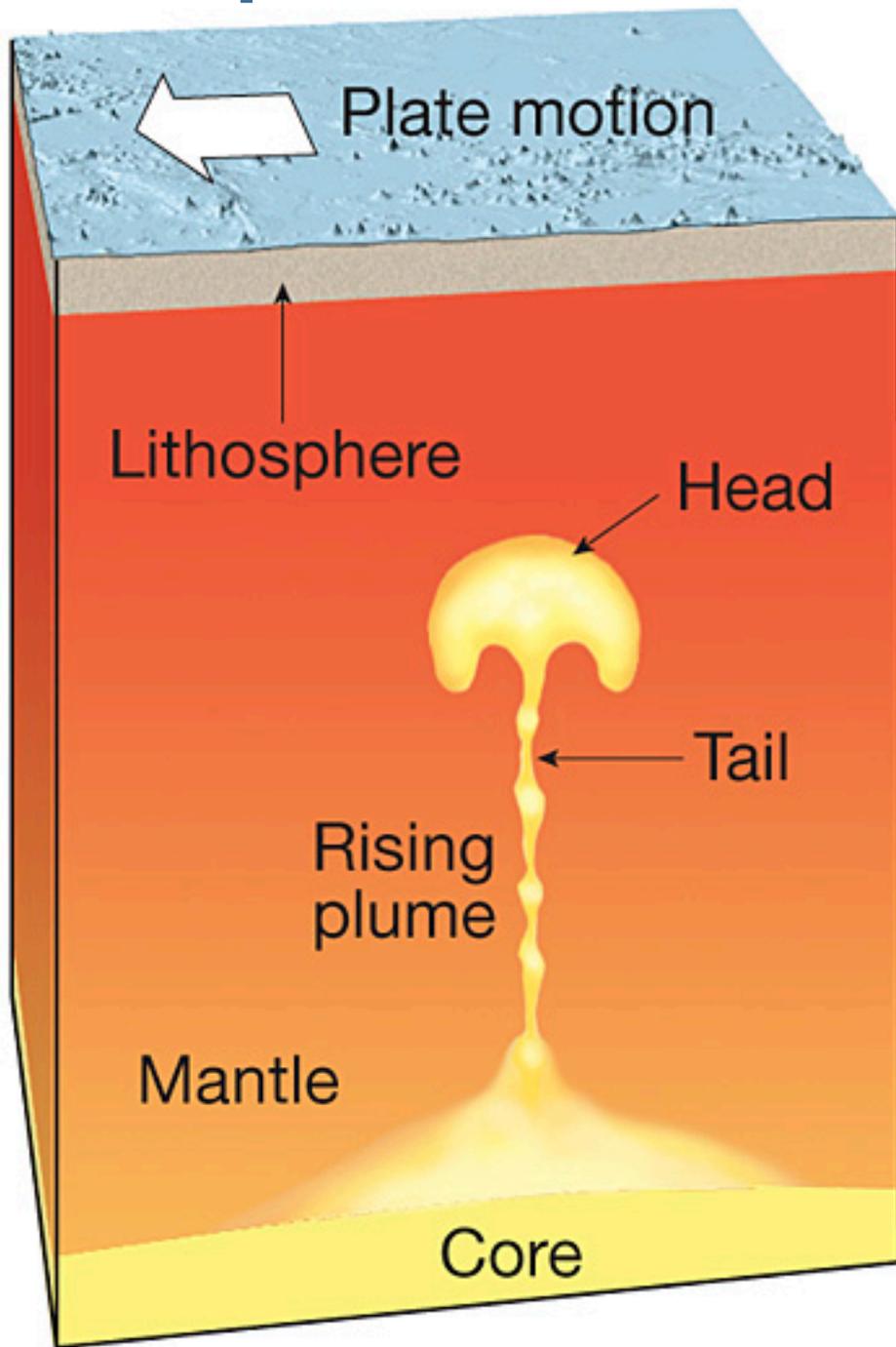
<https://www.youtube.com/watch?v=cQVoSyVu9rk>

# Hot Spots

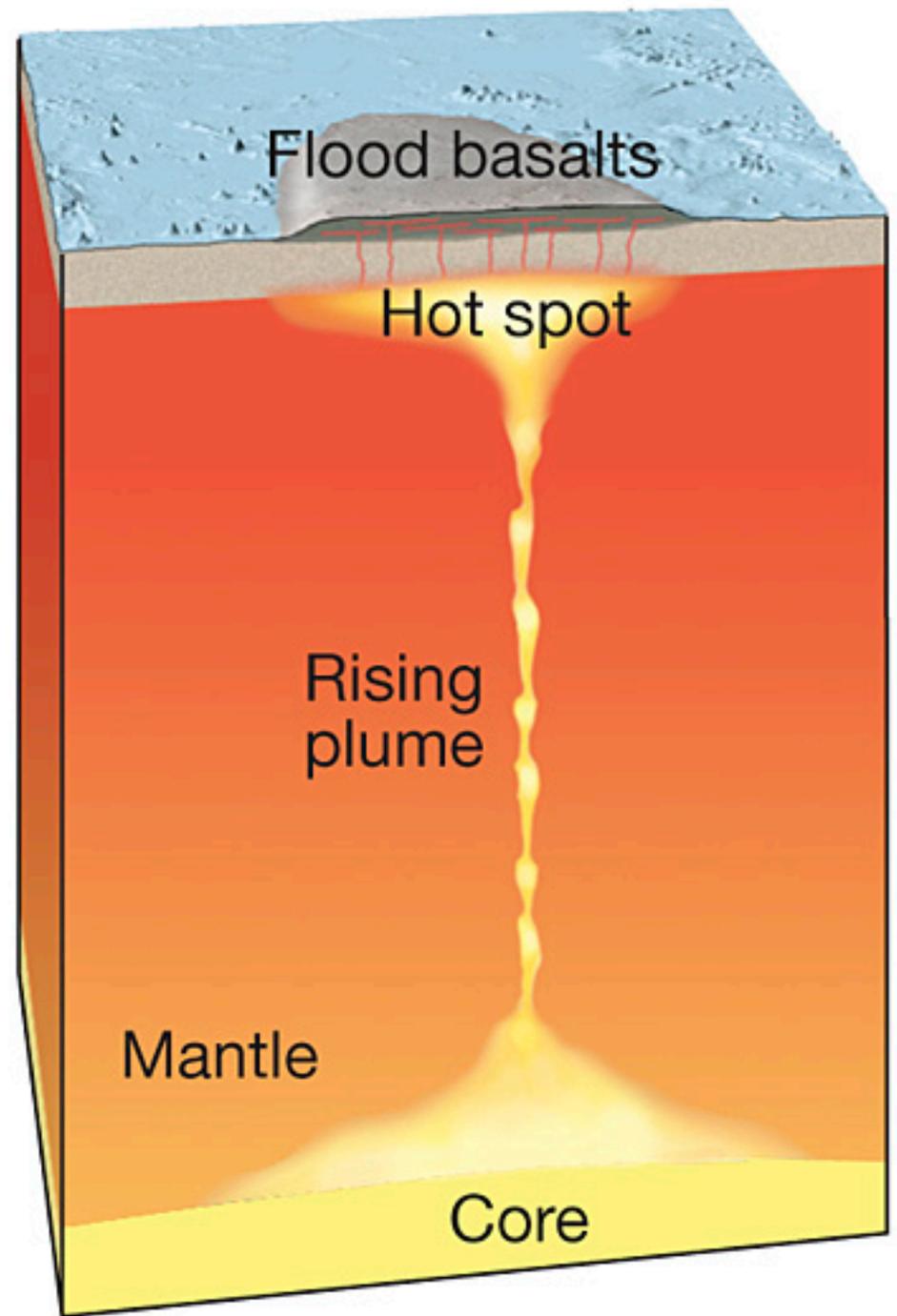


- The Hawaiian islands have formed where a plate is moving over a volcanic hot spot.

# Hot Spots



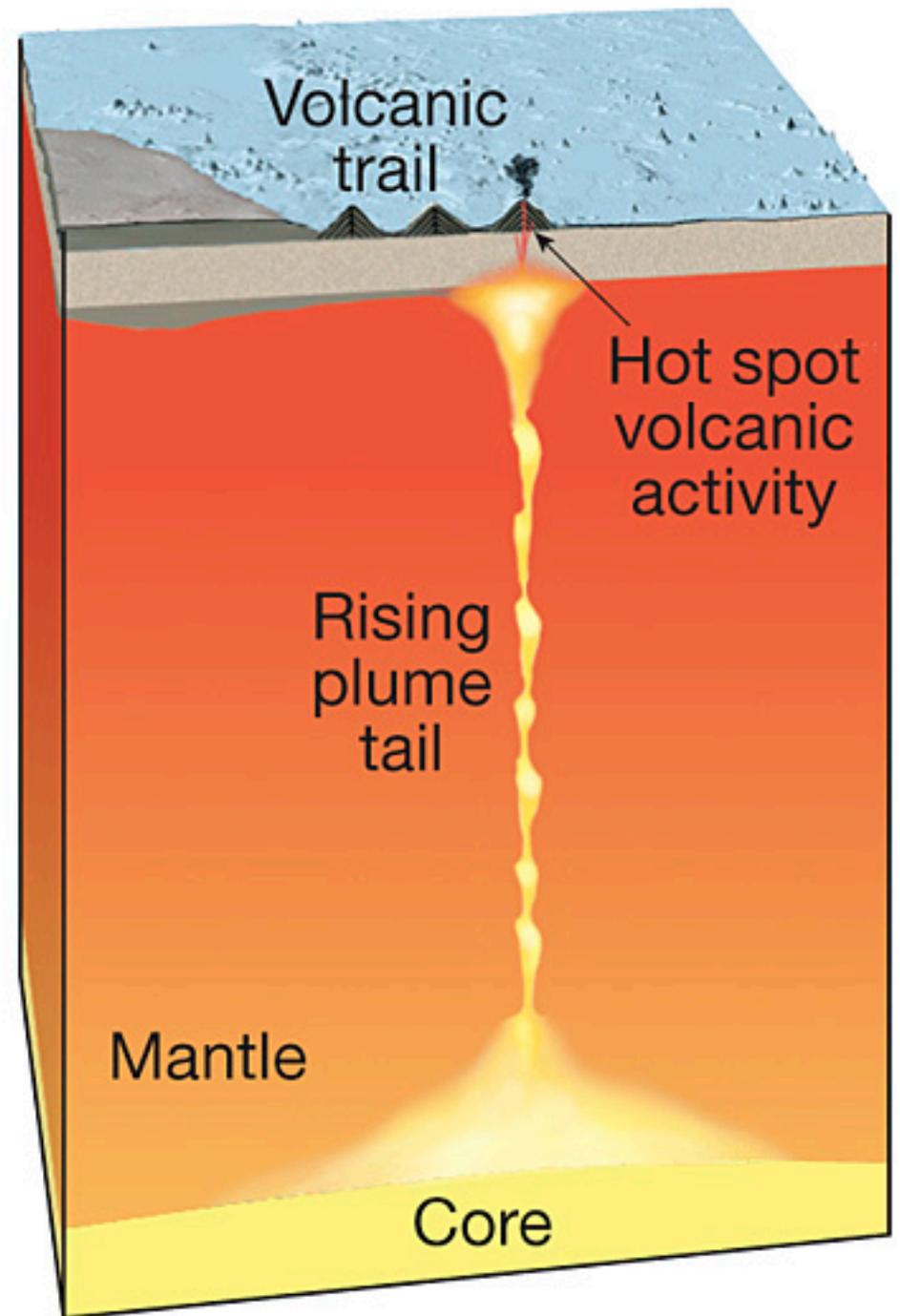
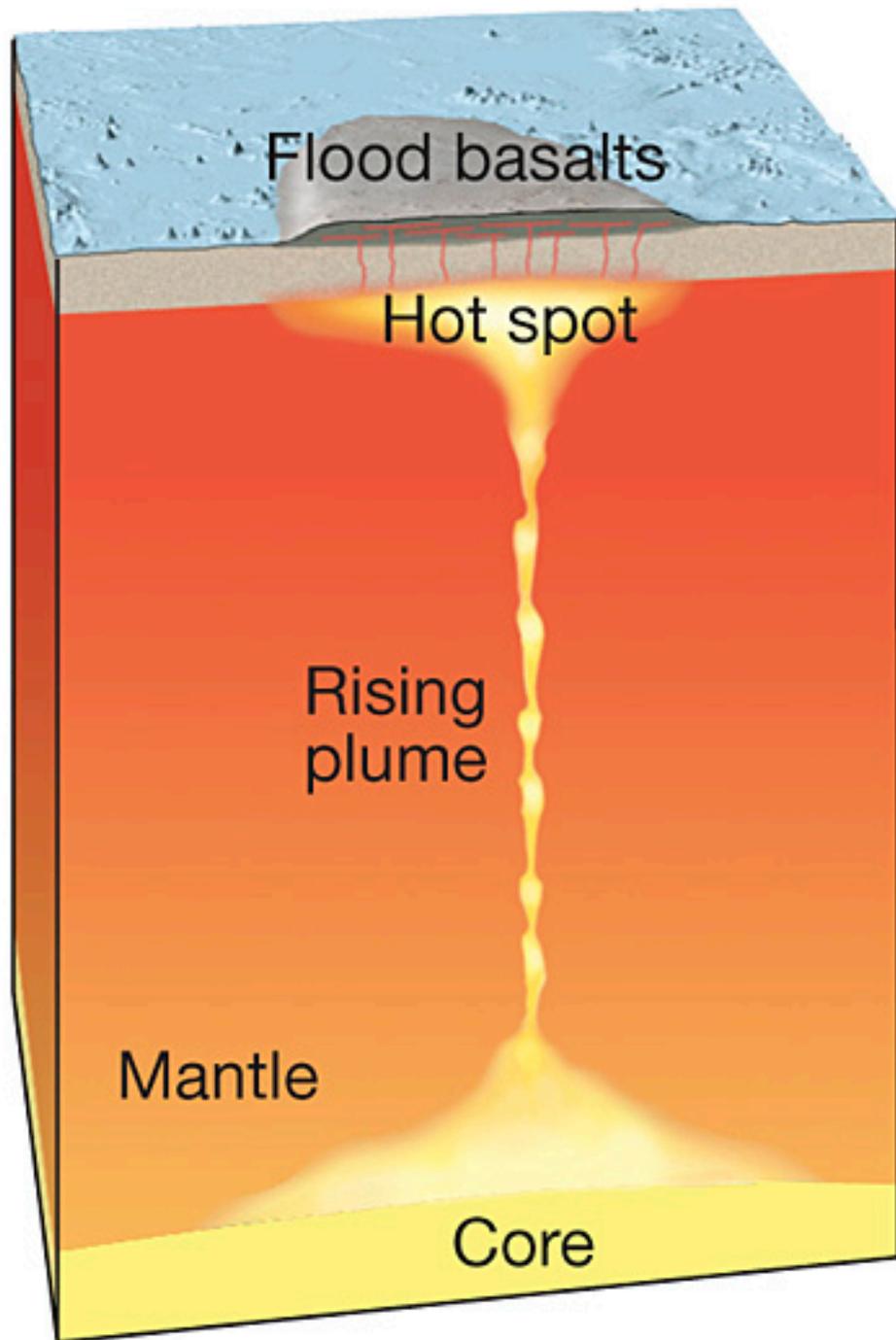
A.



B.

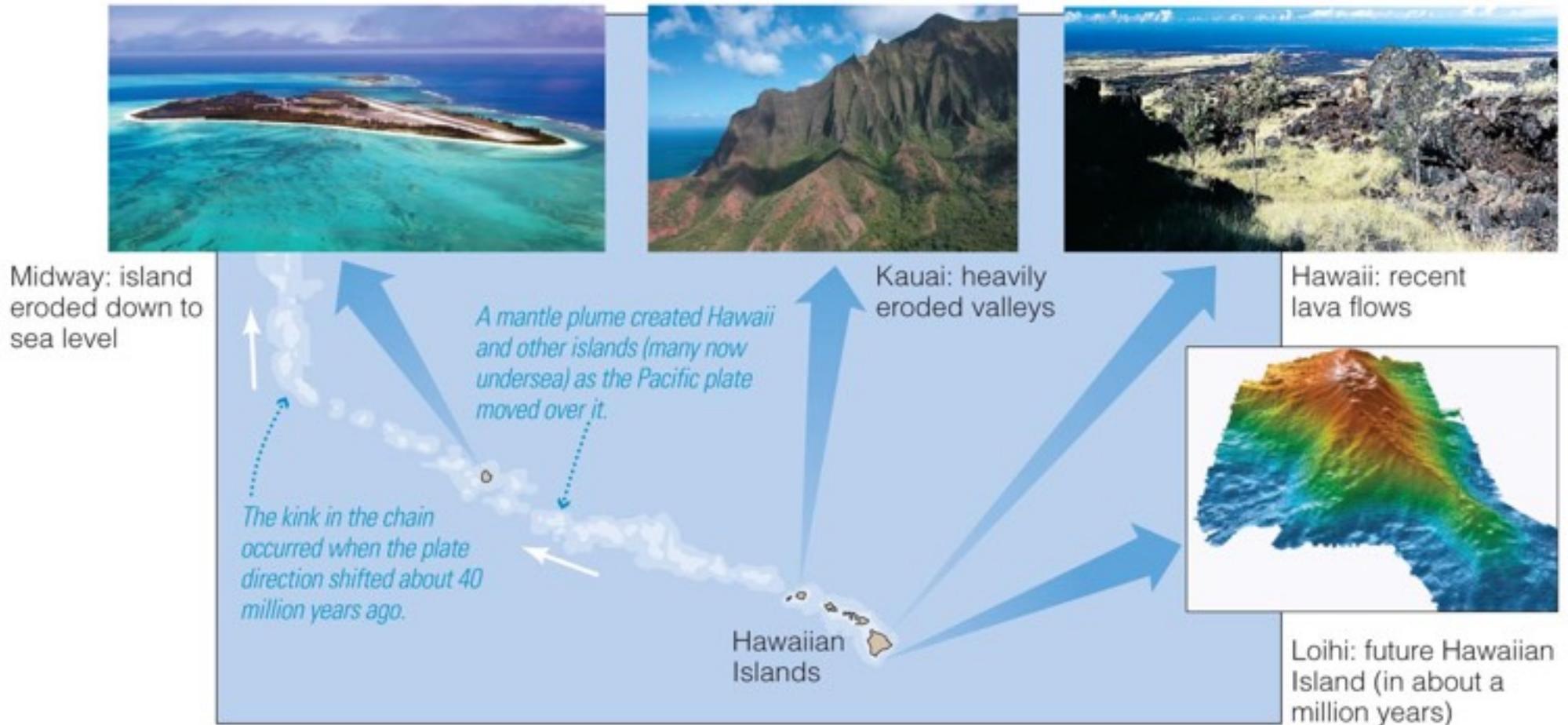
C.

# Hot Spots



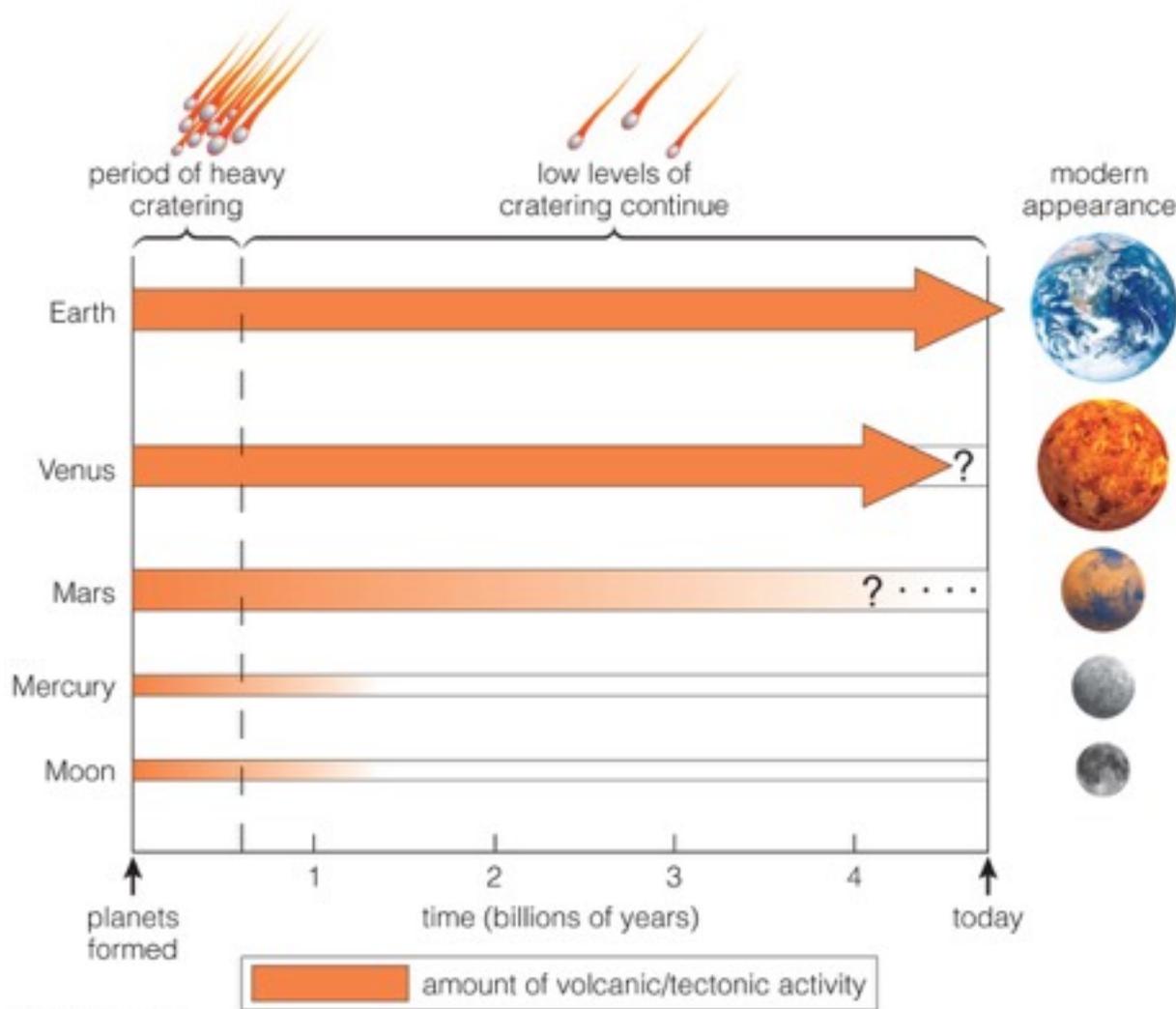
# Hot Spots

*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?



- 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.

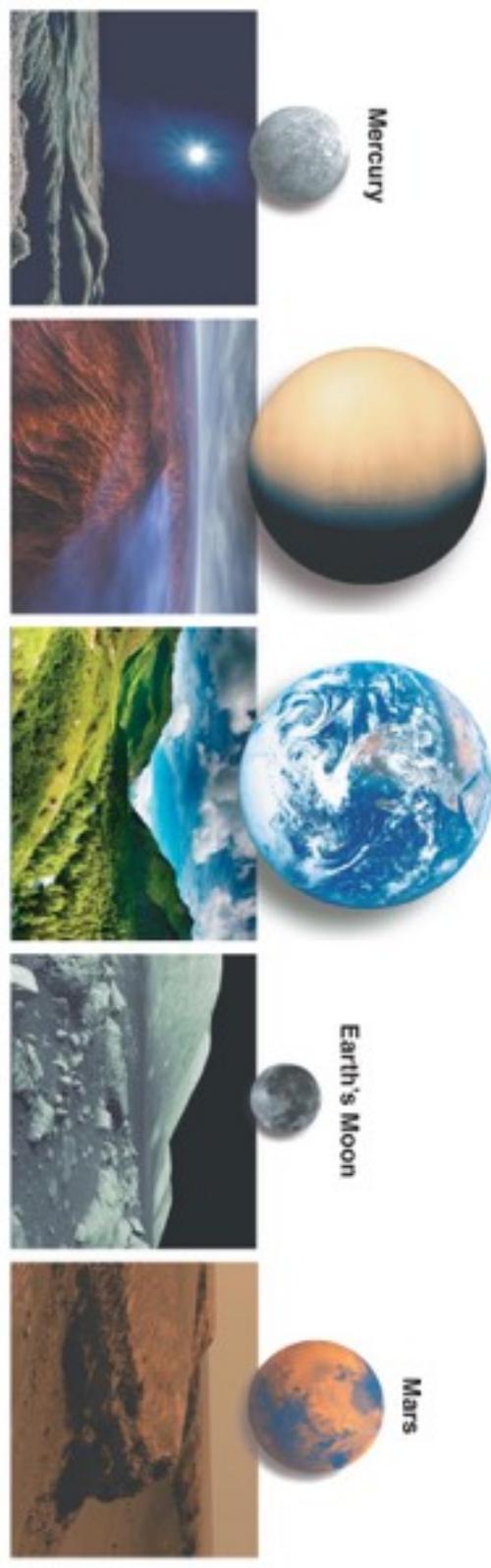
# What have we learned?

- **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 world.
  - 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 <sub>2</sub> 3.5% N <sub>2</sub>	90	878
Earth	78% N <sub>2</sub> 21% O <sub>2</sub> <1% H <sub>2</sub> O, CO <sub>2</sub>	1	59 (global ave)
Moon	N/A	0	257 -283
Mars	95% CO <sub>2</sub> 2.7% N <sub>2</sub>	0.007	-58

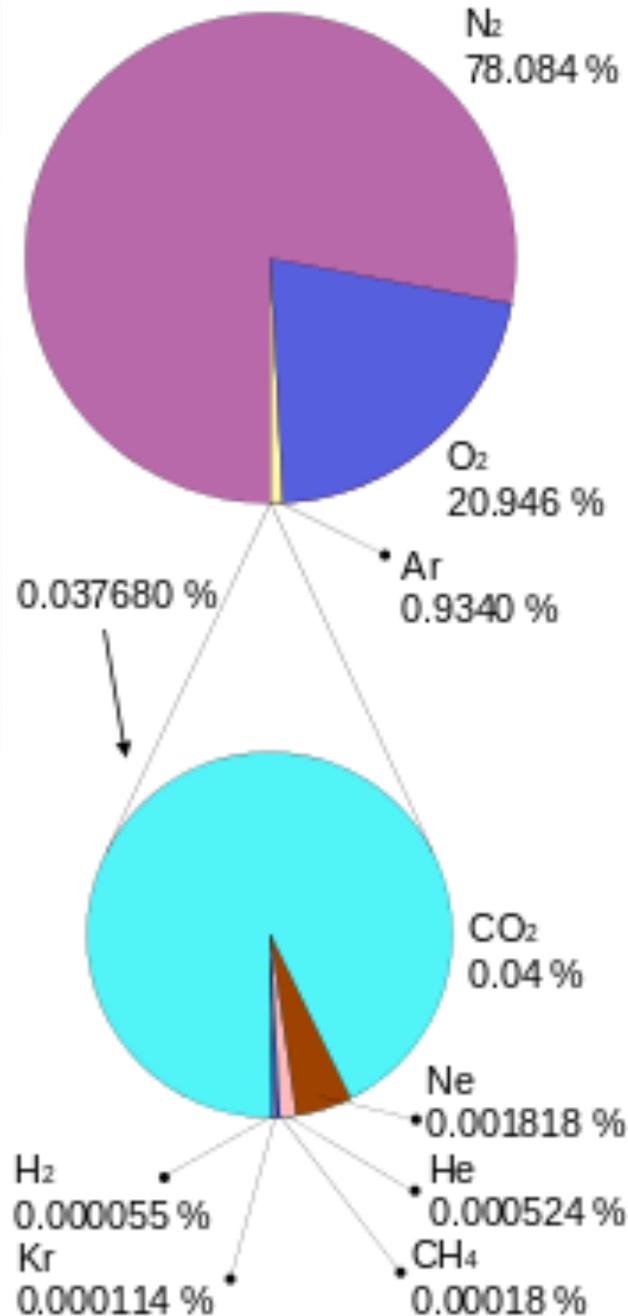
Earth Atm

Farenheit



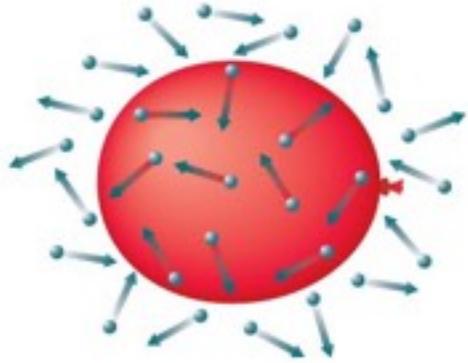
	Composition	Breathing?	Result
Mercury	N/A	nothing to breathe	death
Venus	96% CO <sub>2</sub> 3.5% N <sub>2</sub>	poisonous	death
Earth	78% N <sub>2</sub> 21% O <sub>2</sub> <1% H <sub>2</sub> O, CO <sub>2</sub>	oxygen	life
Moon	N/A	nothing to breathe	death
Mars	95% CO <sub>2</sub> 2.7% N <sub>2</sub>	very little to breathe	death

# Earth's Atmosphere

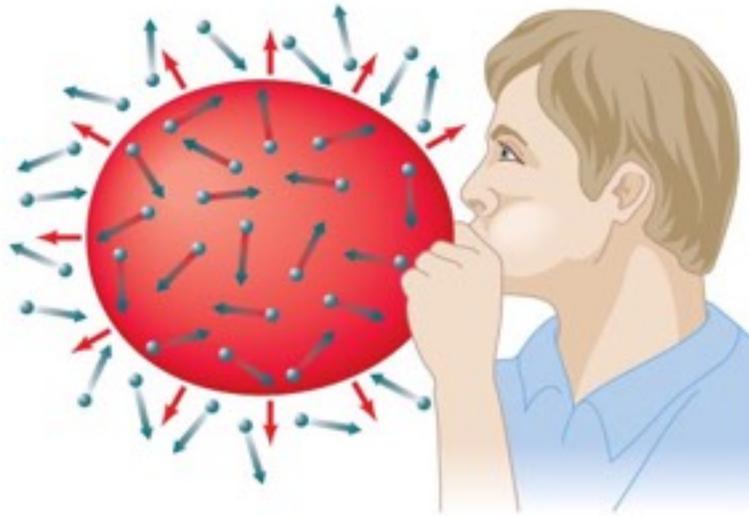


- About 10 kilometers thick, crudely speaking
- 78% N<sub>2</sub>
- 21% O<sub>2</sub>
- 1% Argon
- 0.4% H<sub>2</sub>O (variable)
  - “humidity”
- 0.04% CO<sub>2</sub>
- 0.00018% CH<sub>4</sub>

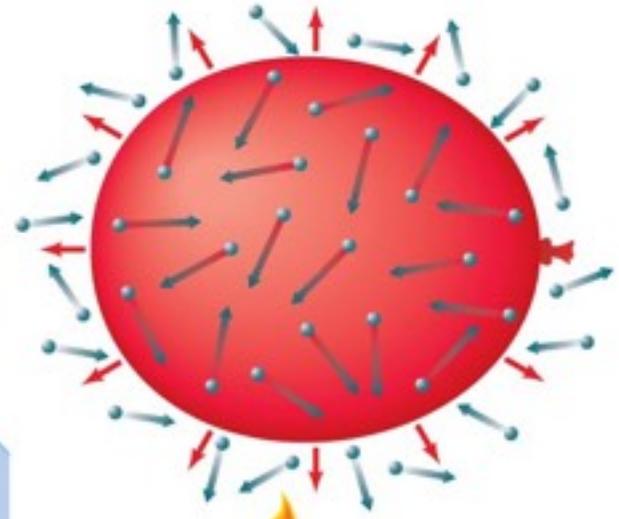
# Atmospheric Pressure



a A balloon stays inflated when the inside and outside pressures are balanced.



b Adding air molecules temporarily increases the pressure inside the balloon, so the balloon expands until the pressure balance is restored.



c Heating the balloon increases the speeds of air molecules inside it, thereby increasing the inside pressure. Again, the balloon expands until the pressure balance is restored.

$$P = NkT$$

○ → Temperature

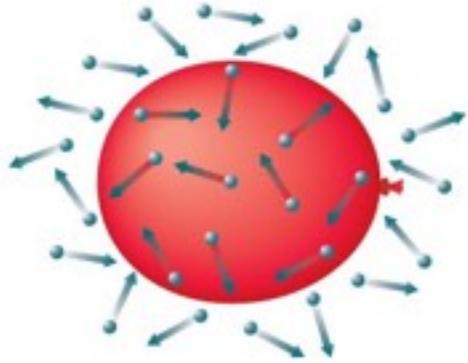
○ → Number density (# molecules per cubic centimeter)

○ → Pressure

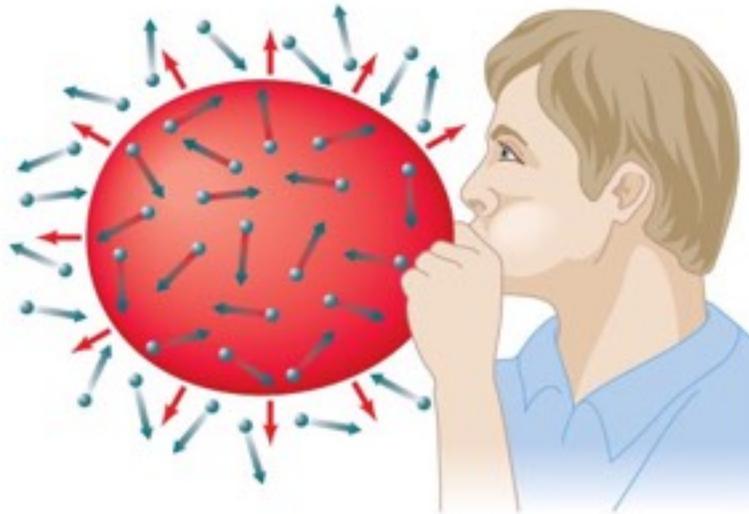
More stuff ○ → higher pressure

Higher temperature ○ → higher pressure

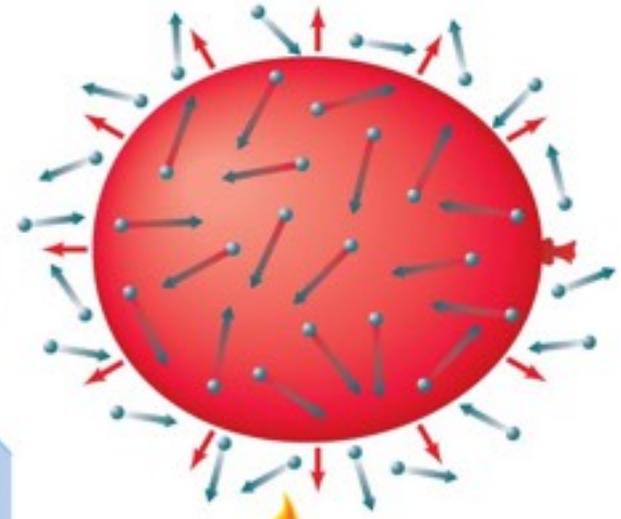
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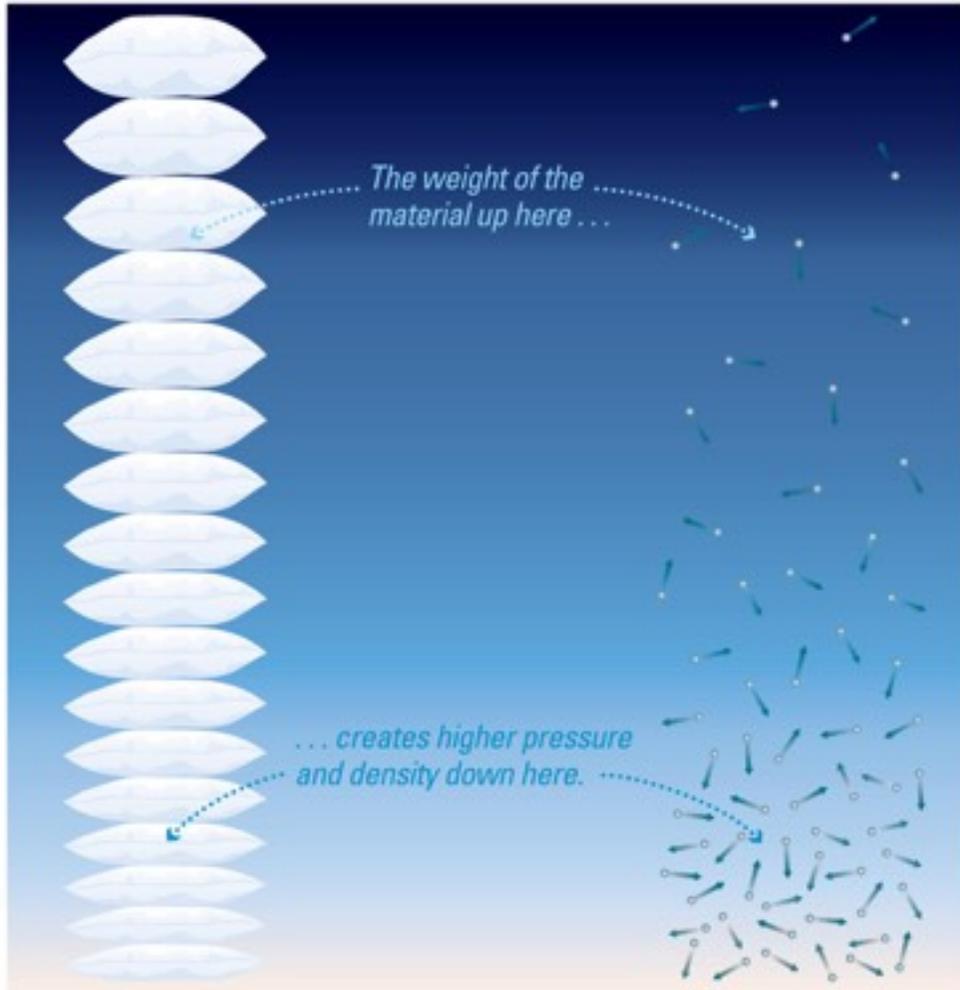


c Heating the balloon increases the speeds of air molecules inside it, thereby increasing the inside pressure. Again, the balloon expands until the pressure balance is restored.

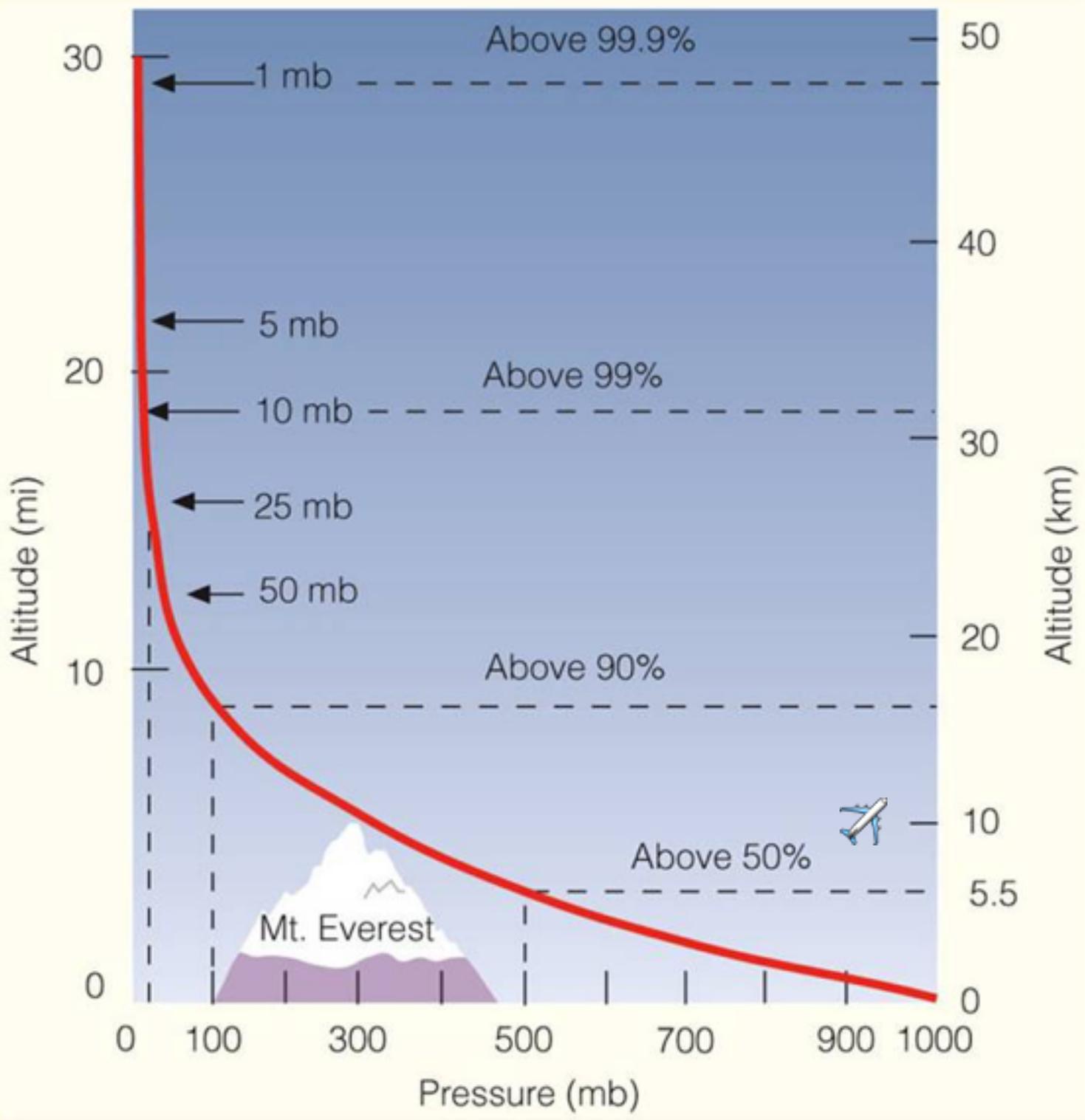
Things exist in pressure equilibrium with their surroundings:

- balloons
- sea level
- people (that's why your ears pop at high altitude, or you get the bends if you come up too fast from a deep dive)

# Atmospheric Pressure



- Pressure and density decrease with altitude because the weight of overlying layers is less.
- Earth's pressure at sea level is:
  - 1.03 kg per sq. meter
  - 14.7 lb per sq. inch
  - 1 bar



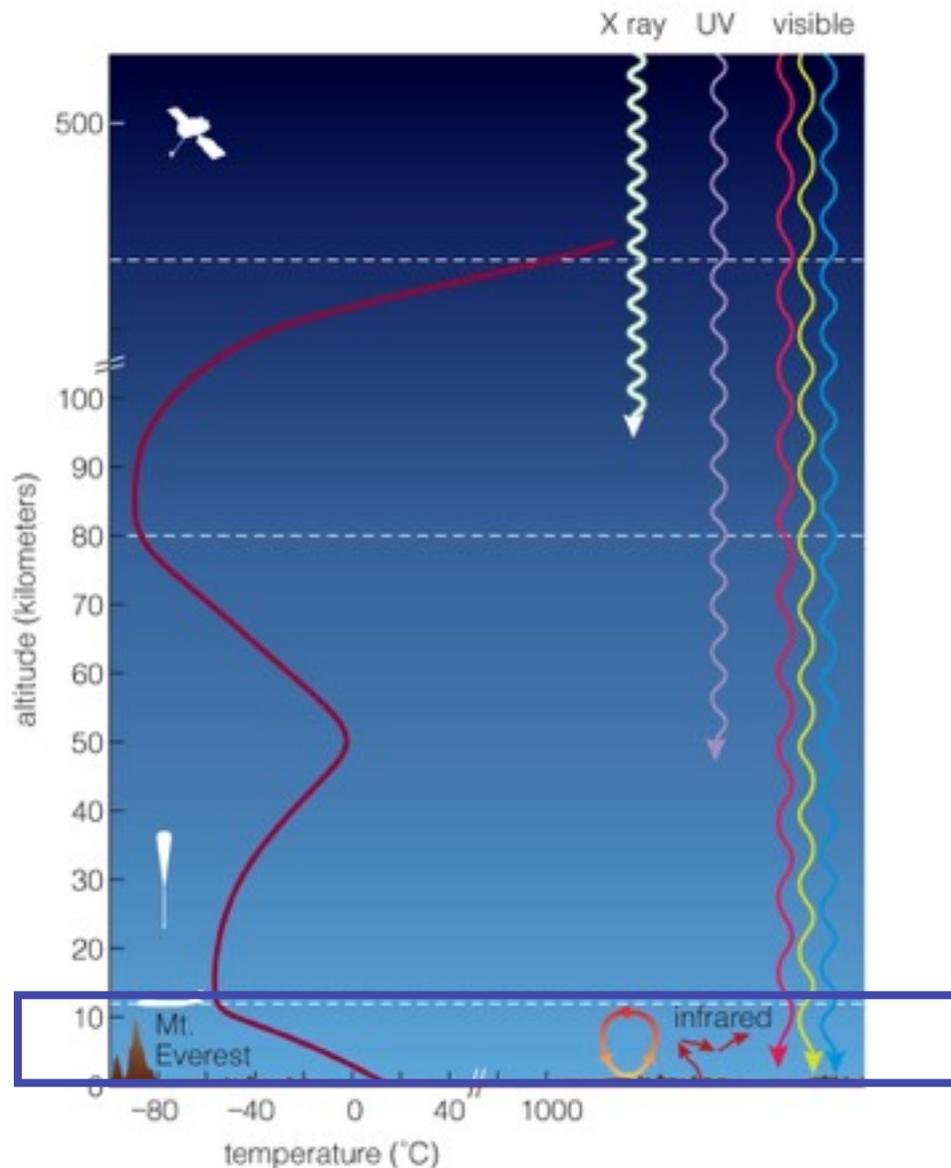
Atmospheric density and pressure decline with increasing altitude.

There is no clear “edge” to the atmosphere - just an exponential attenuation.

Jet cruising altitude ~ 10 km

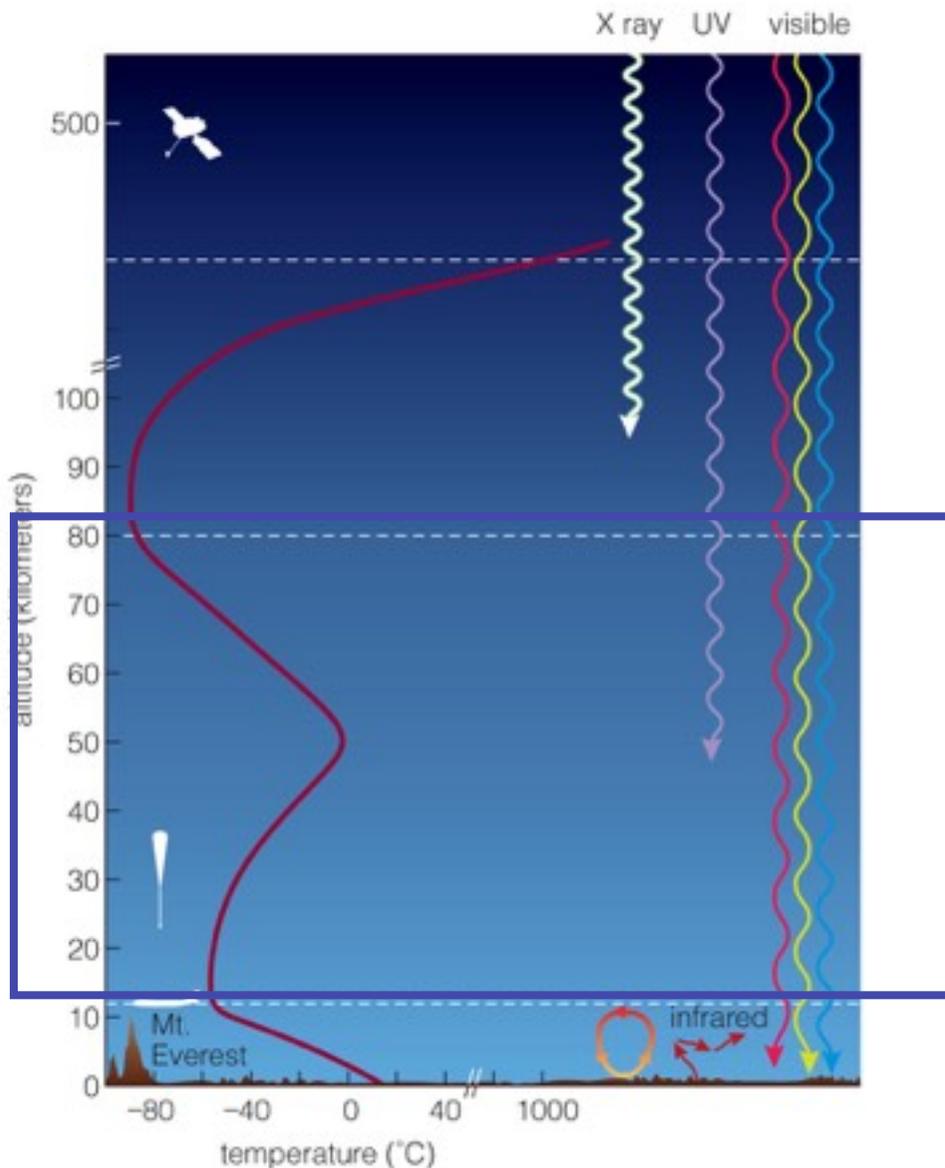
Death zone: > 8 km

# Earth's Atmospheric Structure



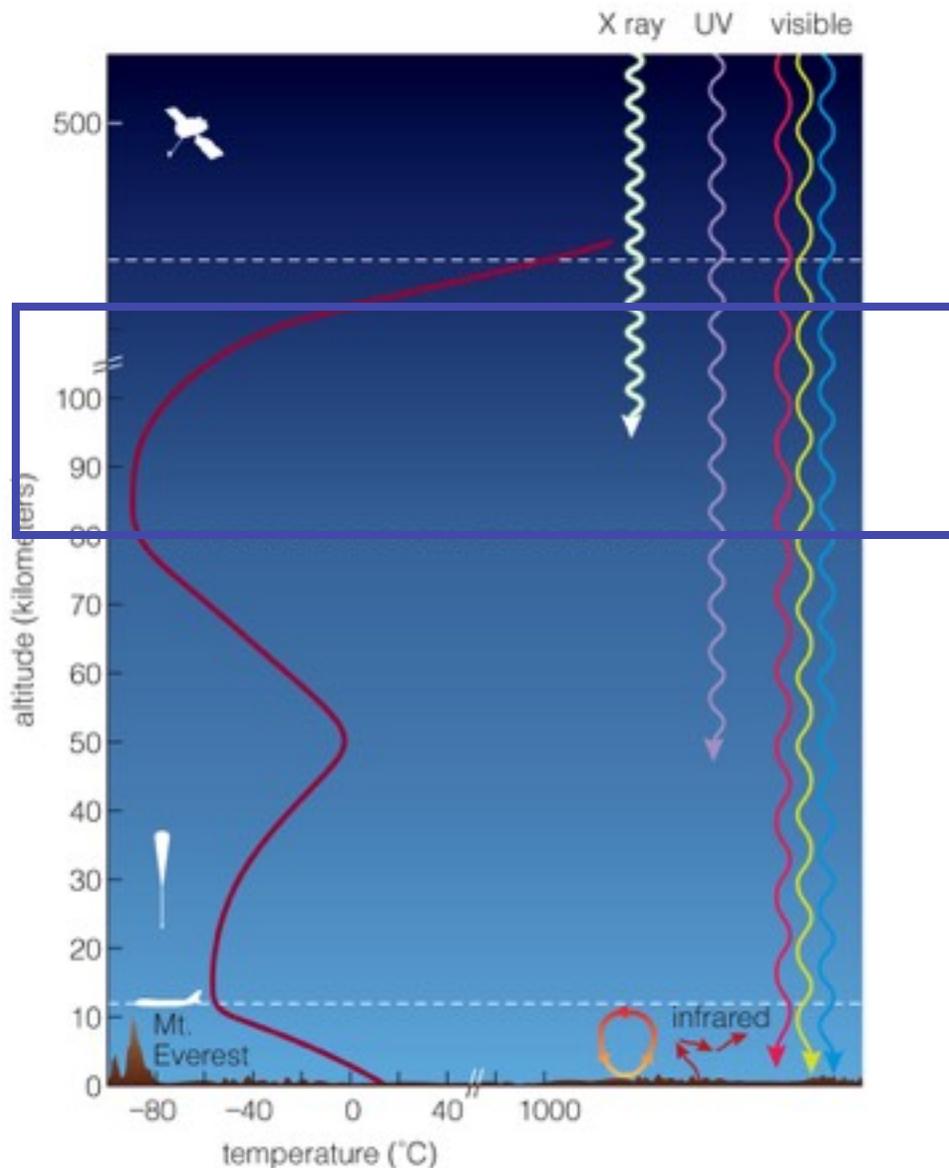
- **Troposphere:** lowest layer of Earth's atmosphere
- Temperature drops with altitude.
- Warmed by infrared light from surface and convection

# Earth's Atmospheric Structure



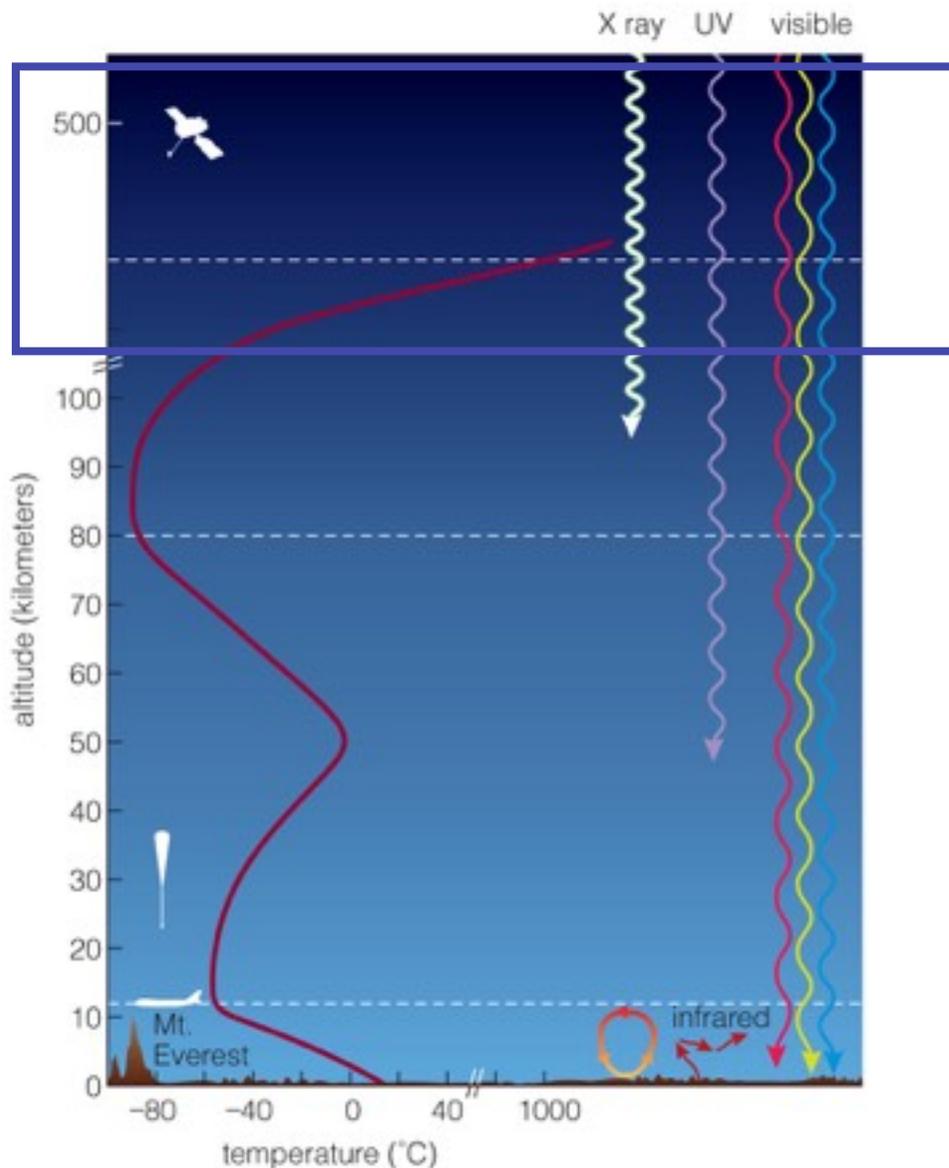
- **Stratosphere:** layer above the troposphere
- Temperature rises with altitude in lower part, drops with altitude in upper part.
- Warmed by absorption of ultraviolet sunlight

# Earth's Atmospheric Structure



- **Thermosphere:** layer at about 100 kilometers altitude
- Temperature rises with altitude.
- X rays and ultraviolet light from the Sun heat and ionize gases.

# Earth's Atmospheric Structure



- **Exosphere:** highest layer in which atmosphere gradually fades into space
- Temperature rises with altitude; atoms can escape into space.
- Warmed by X rays and UV light

# Planetary climates

- Temperature depends on balance between
- Heat input from sun
  - distance dependent
  - albedo dependent (reflection vs. absorption)
- Heat loss to space
  - atmosphere dependent (natural greenhouse effect)
  - heat trapping “greenhouse” gases (e.g., H<sub>2</sub>O, CO<sub>2</sub>) important even if only present in trace quantities
    - they are the IR-opaque shade to the transparent glass of the primary atmospheric gases

# The Greenhouse Effect

