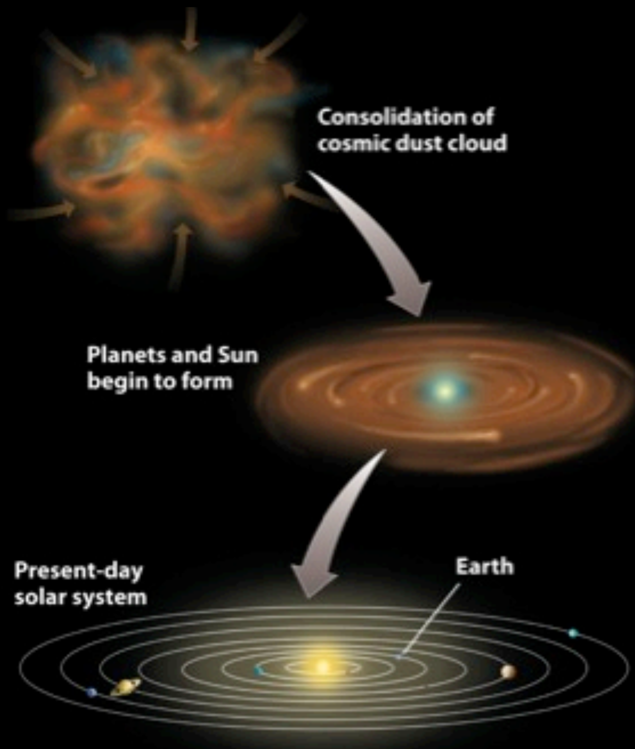
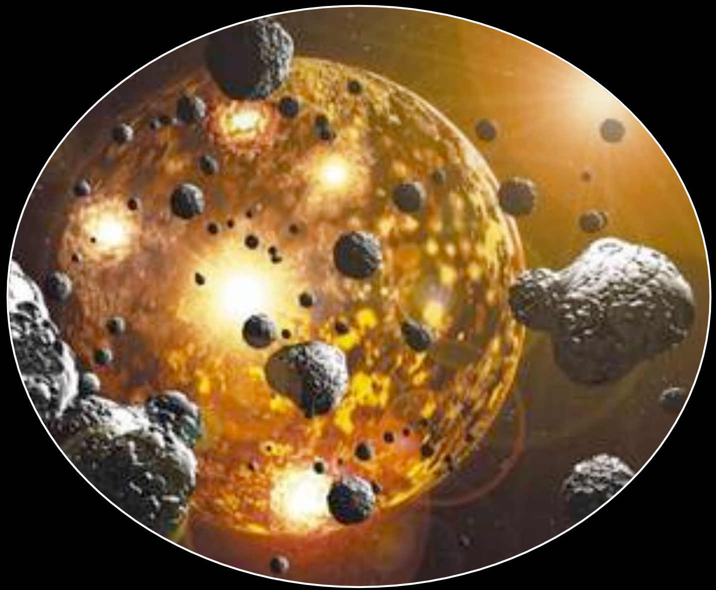
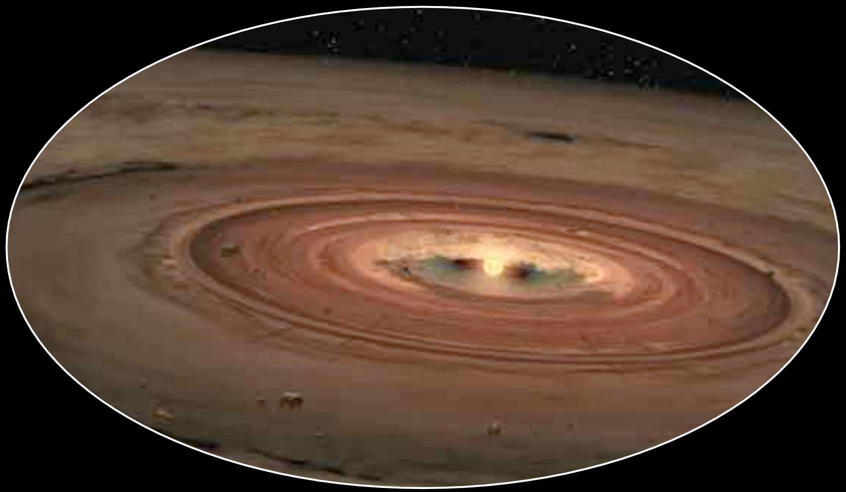
CHAPTER 14

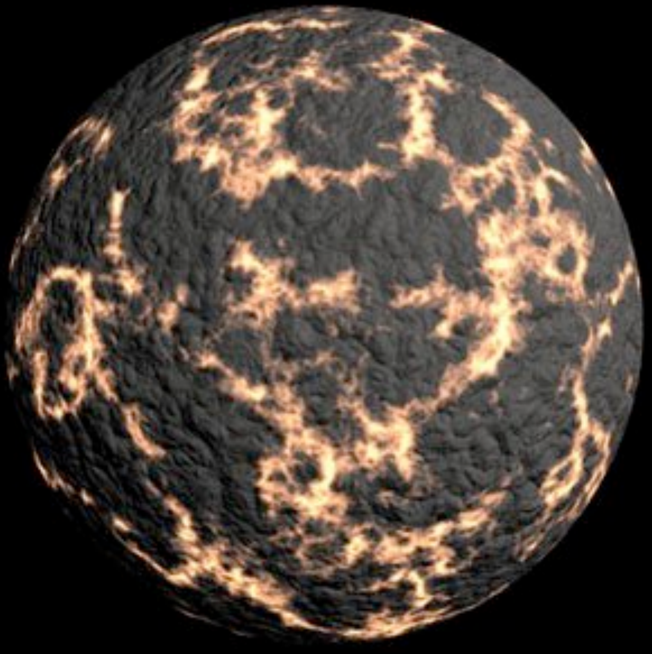
Geology and Nonrenewable Mineral Resources- Part 1

Geologic Processes

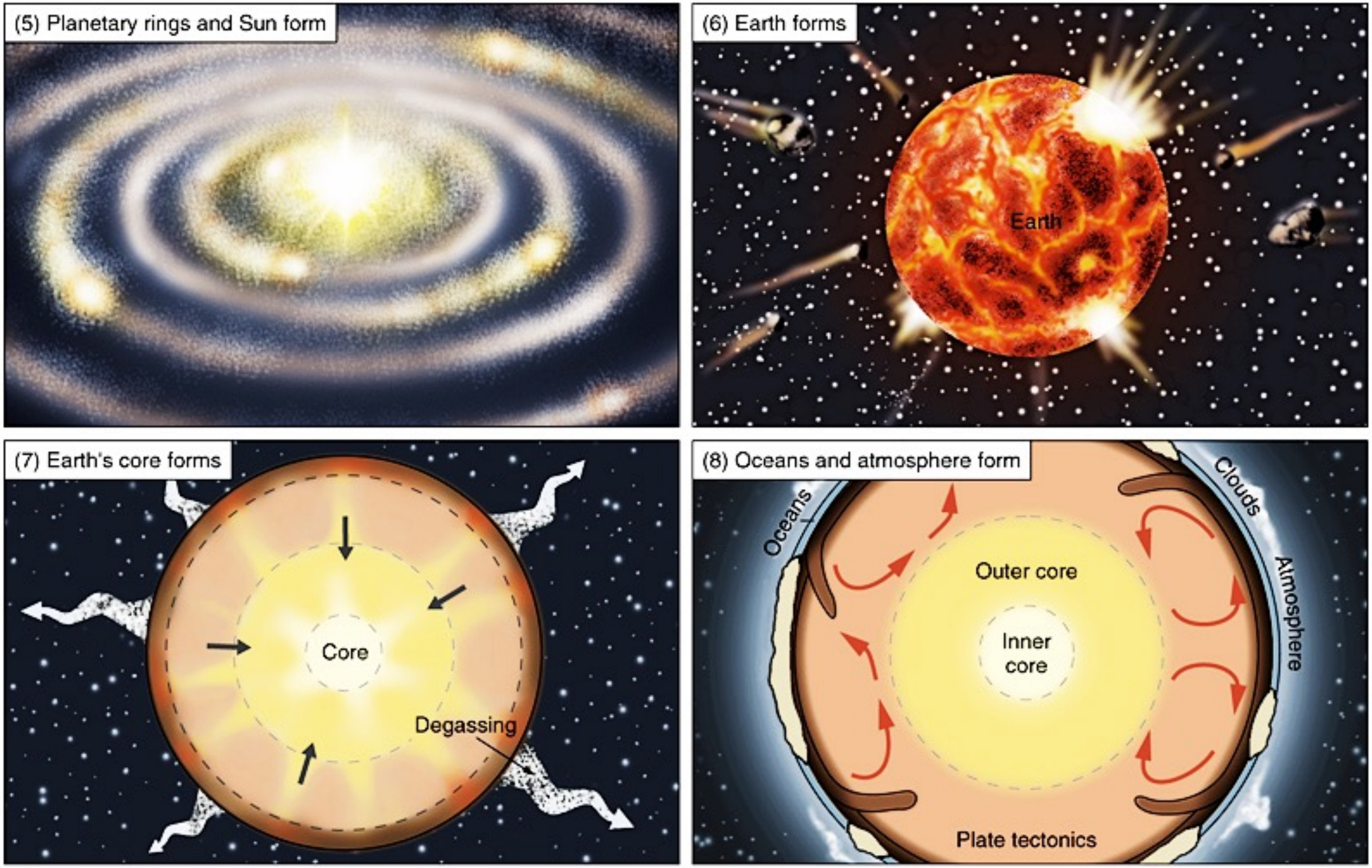




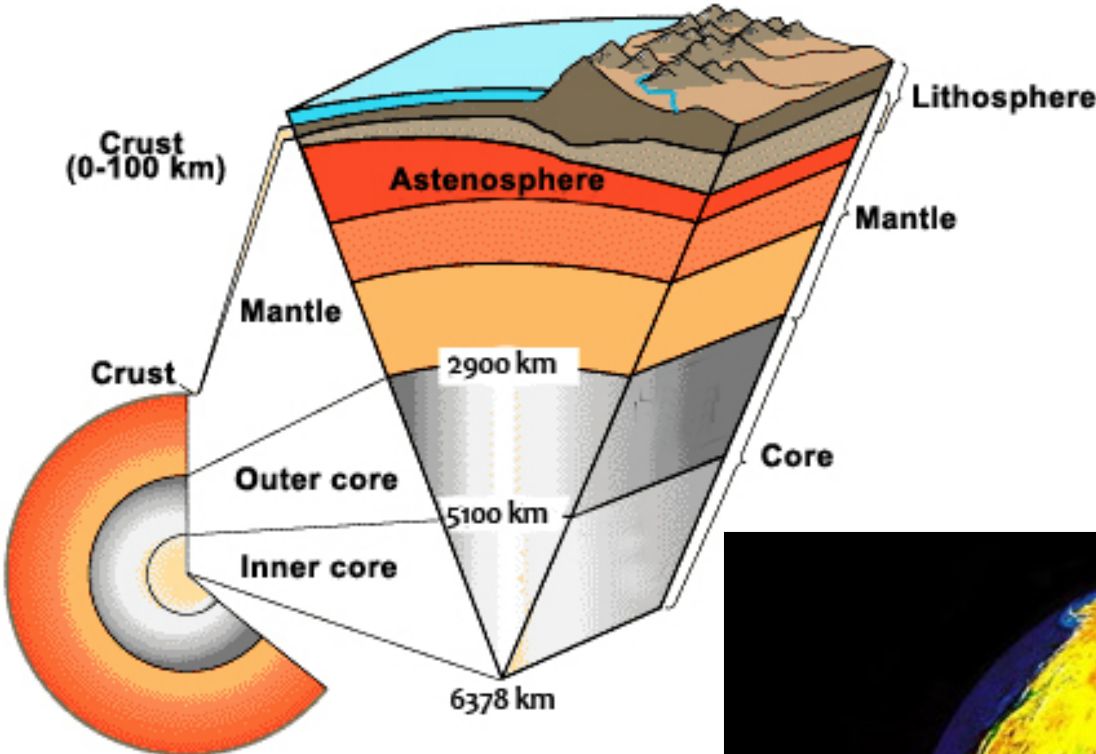


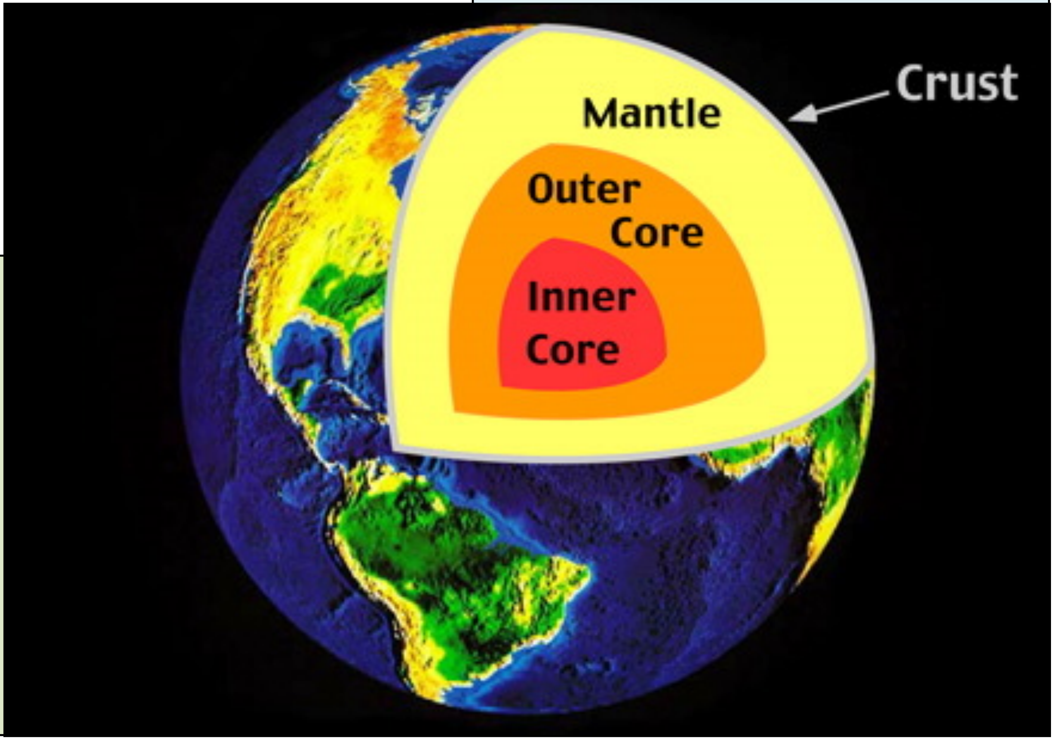


Geologic Processes



Geologic Processes



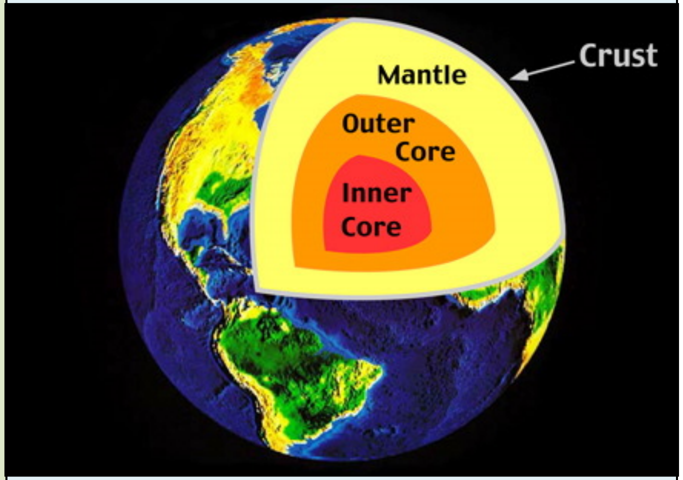


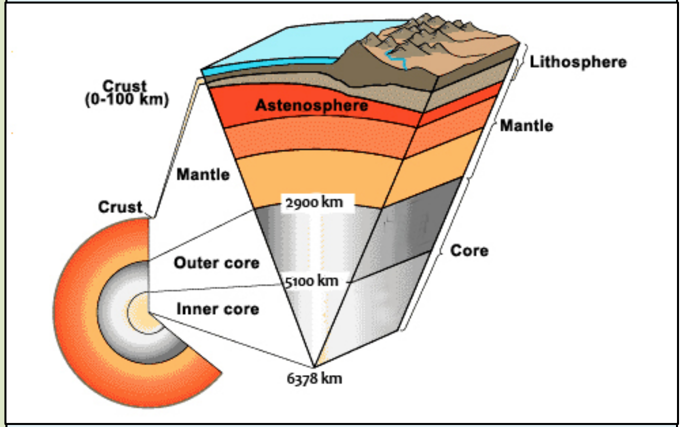
Geologic Processes

Layers of the Earth

Crust

- *Continental crust*: extends 20-30 miles below surface; composed largely of silica-rich rocks such as granite and sandstone; therefore less dense than oceanic crust.
- *Oceanic crust*: extends about 7 miles below surface; composed largely of rocks such as basalt that are rich in heavier elements such as iron and magnesium; thus it is more dense than continental crust.
  - *Lithosphere*: outermost solid rocky crust; i.e. lithospheric crust
  - *Asthenosphere*: semi-molten rock with fluid qualities; flows very slowly, like a stiff liquid.





Geologic Processes

Layers of the Earth

Mantle

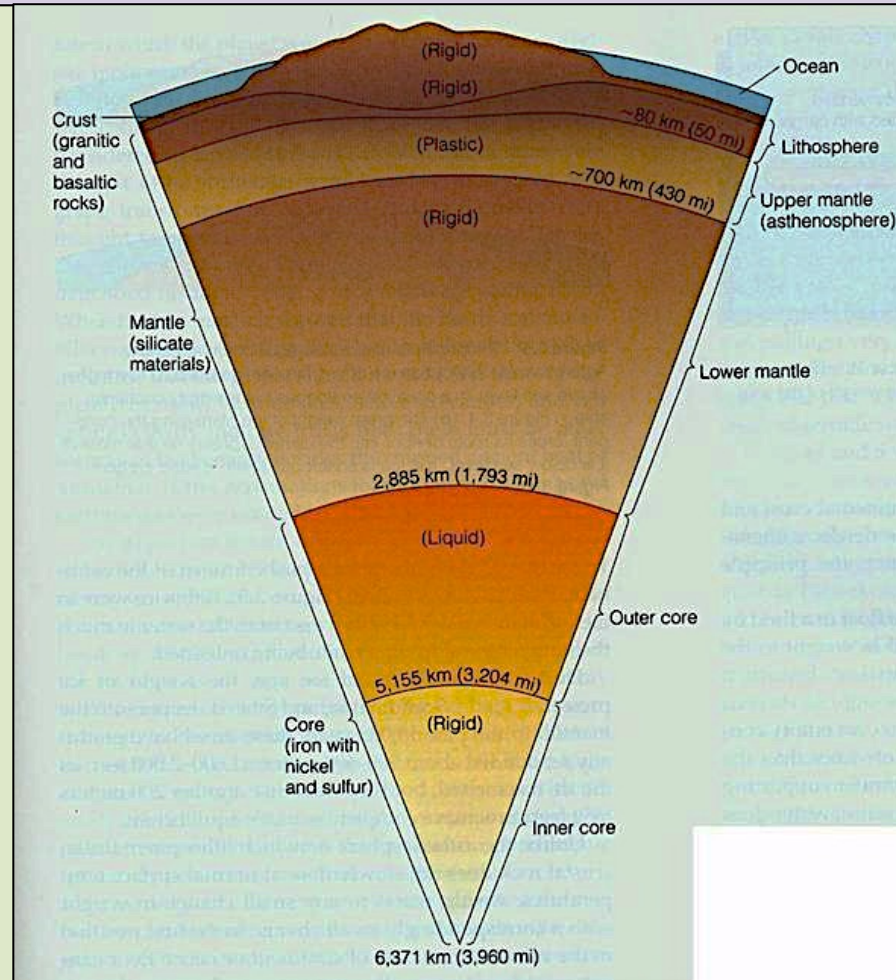
Most of Earth's mass is in the mantle; composed of iron, magnesium, aluminum, and silicon-oxygen compounds (silica); thick solid zone surrounding core (approx. 2,900 km); mostly solid rock but in the "plastic-like" asthenosphere partially melted rock flows slowly forming convection currents as hotter less dense rock being heated by core rises.

Outer Core

Extremely hot; composed of molten/ liquid iron and nickel.

Inner Core

Also extremely hot yet solid iron and nickel due to extreme pressure.

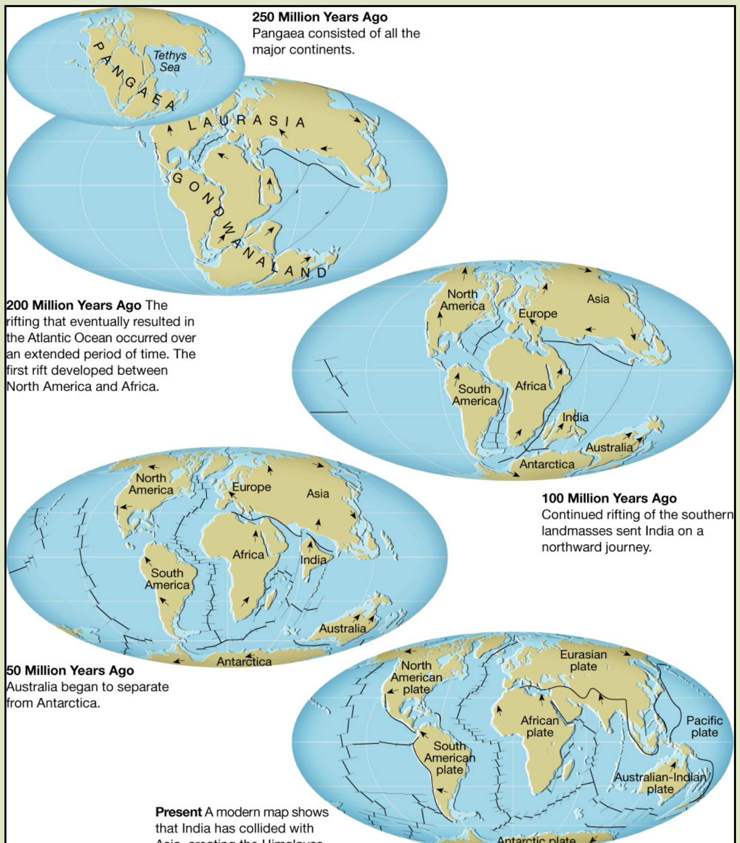


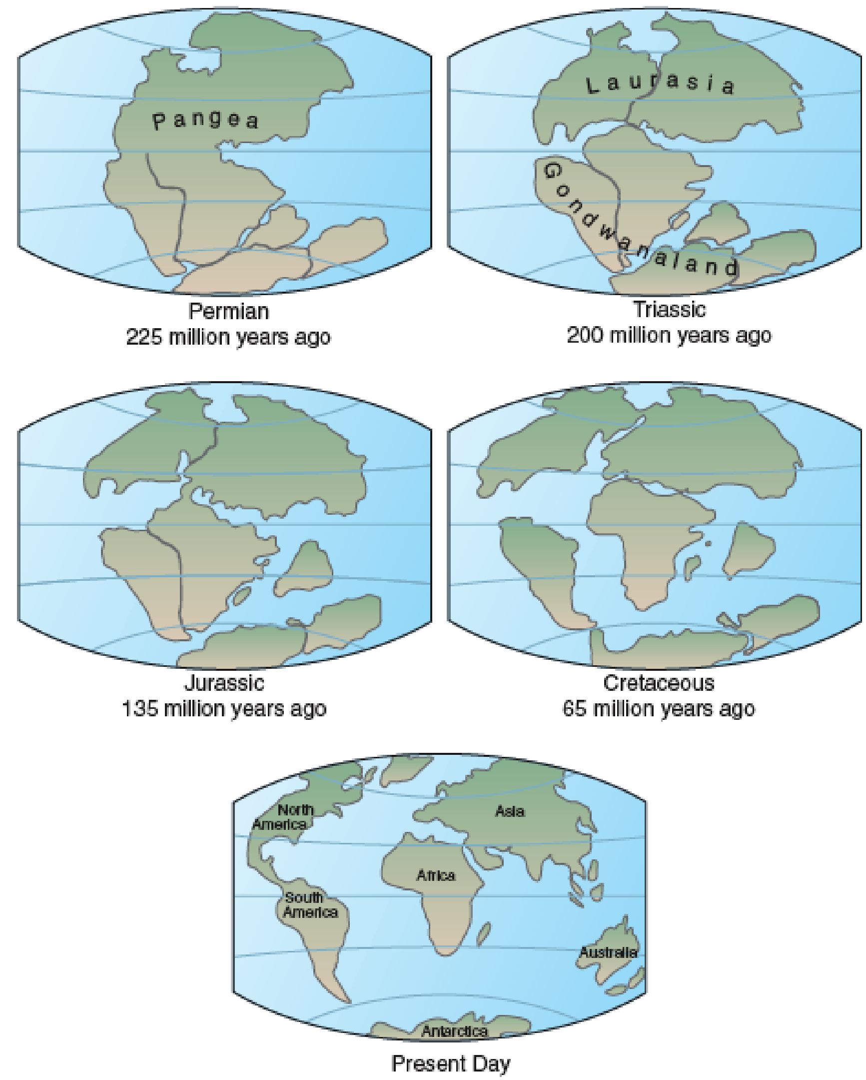
Most of the Earth's internal heat is *remnant heat* from planetary formation. However, a contributing factor that accounts Earth's internal heat is the radioactive decay of K, U, Th in the core, which releases heat.

Geologic Processes

The Continental Drift Theory

In 1915, Alfred Wegener proposed that all of the continents had drifted from their original positions in a supercontinent that he called Pangaea over the last 225-250 million years.

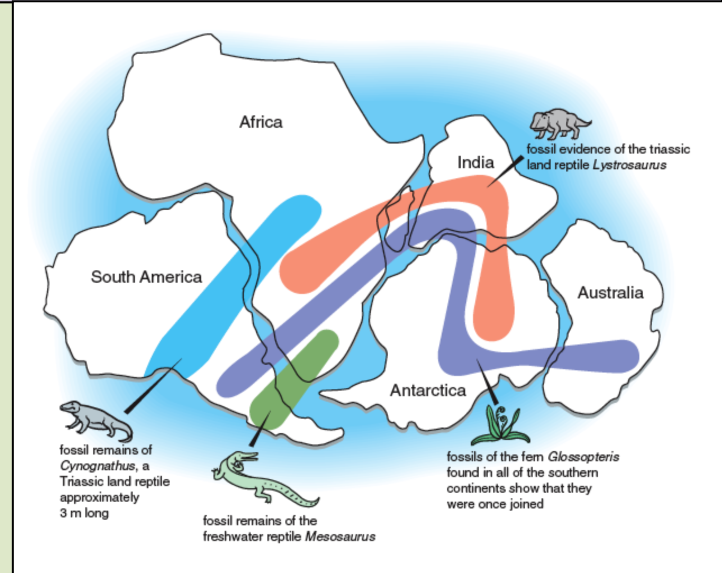




Geologic Processes

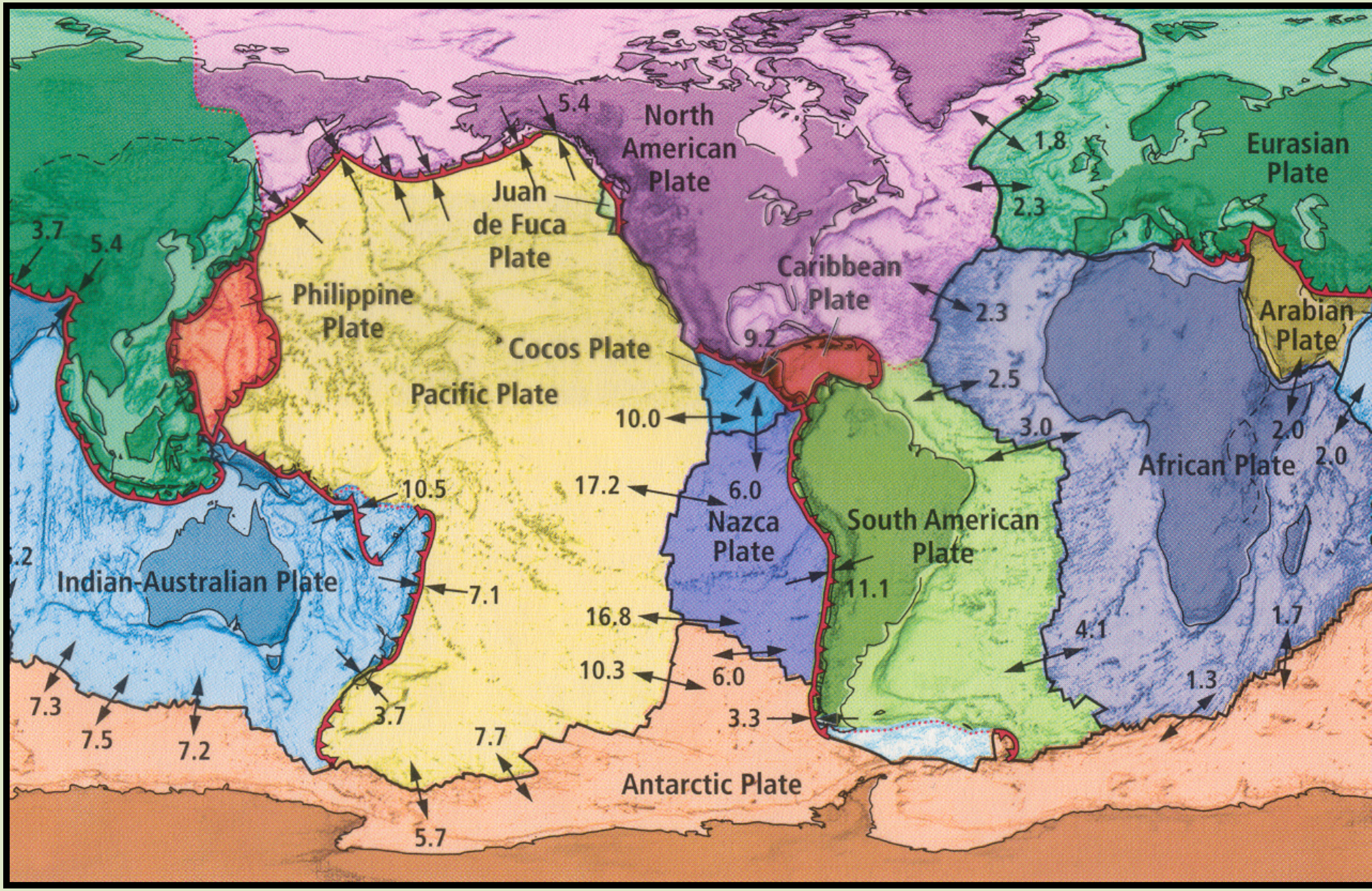
Evidence to support continental drift theory:

1. Fossilized tropical plants were discovered beneath Greenland's icecaps.
2. Glaciated landscapes occurred in the tropics of Africa and South America.
3. Tropical regions on some continents had polar climates in the past, based on paleoclimate data.
4. The continents fit together like a puzzle.
5. Similarities existed in rocks between the east coast of North and south America and the west coasts of Africa and Europe.



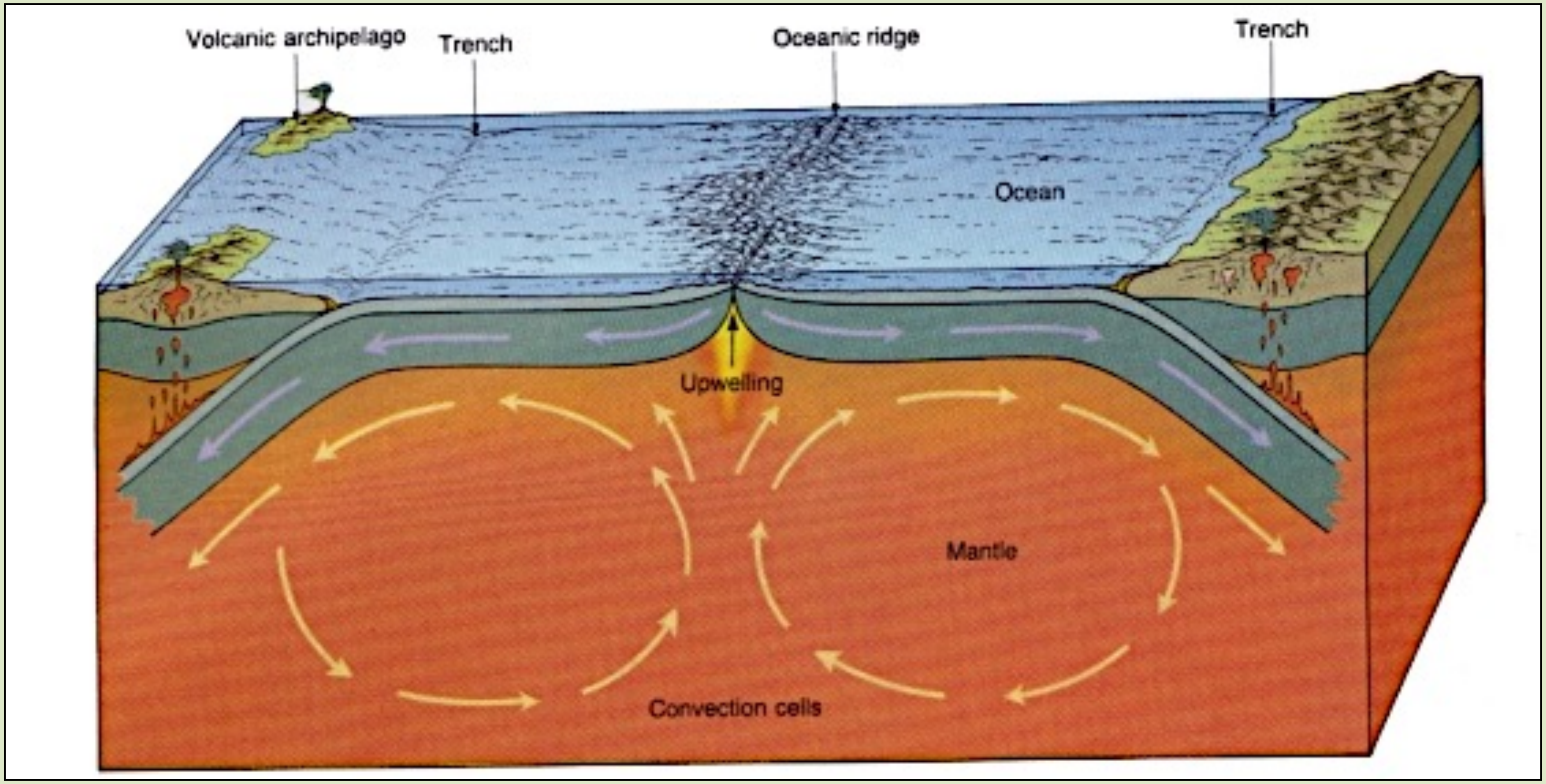
Geologic Processes

Plate Tectonics: the theory that Earth's lithosphere is divided "plates" that are pushed and pulled across the earth's surface by convection cells.



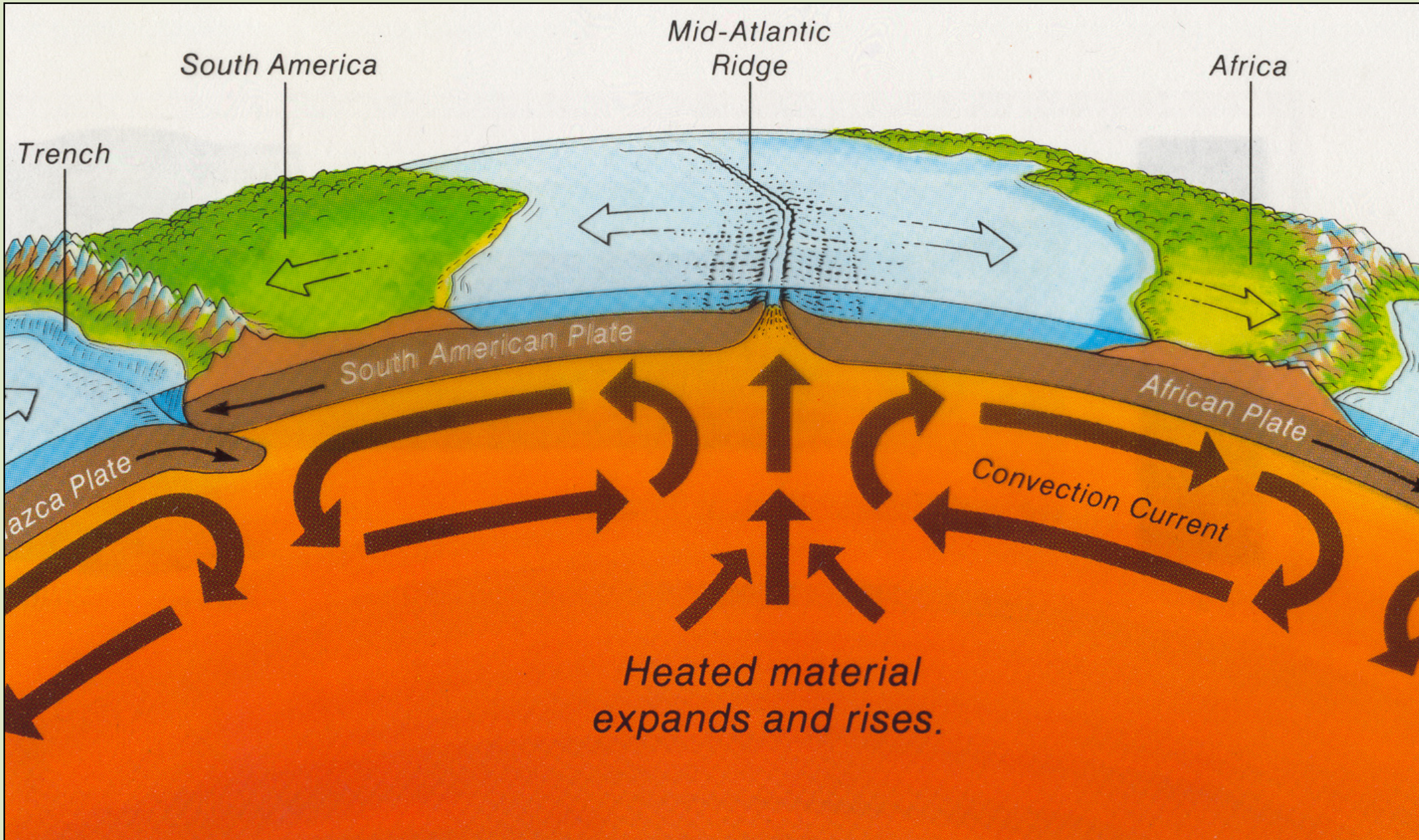
Geologic Processes

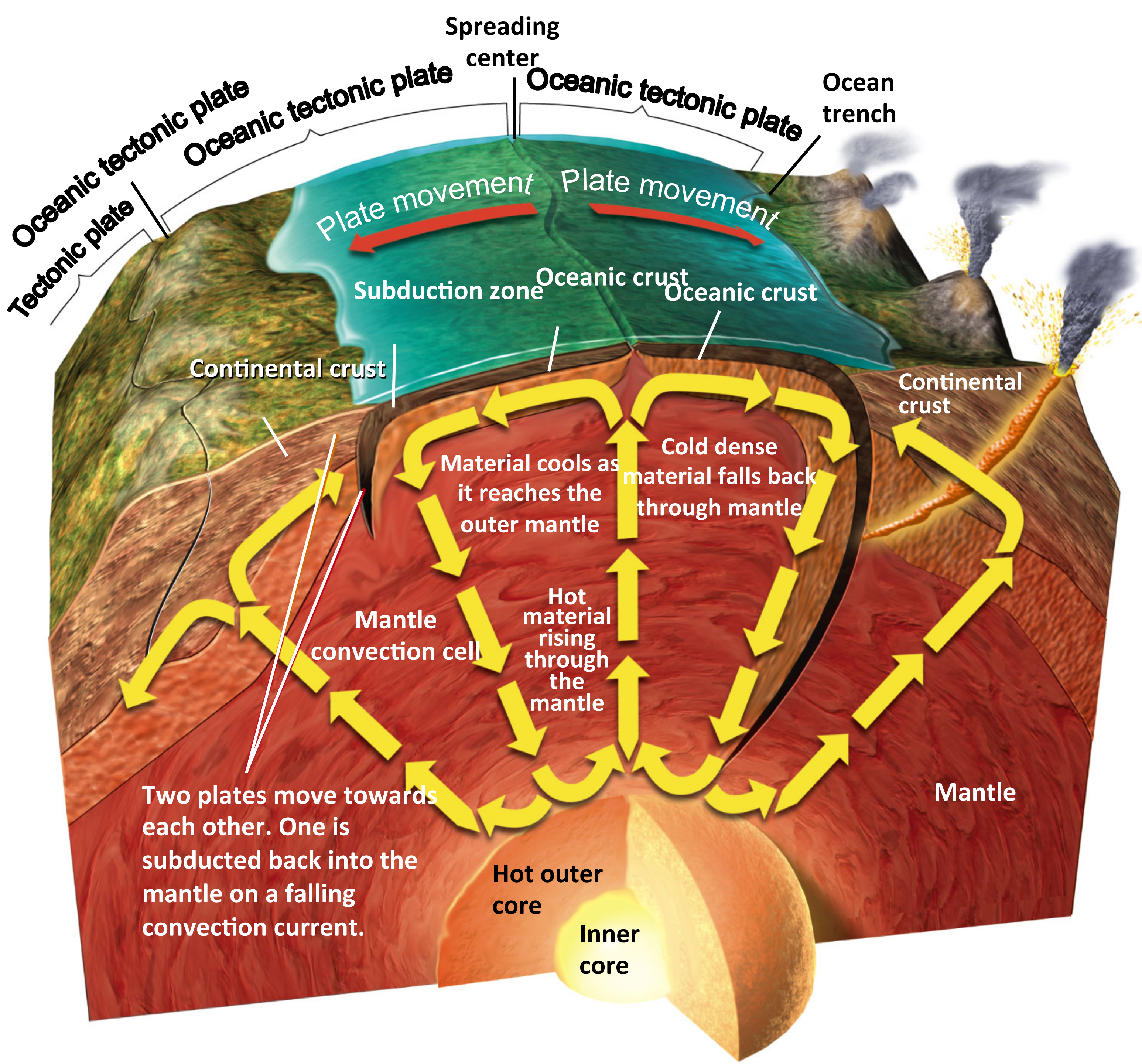
Convection Cells: Within the asthenosphere hot semi-molten rock slowly rises to Earth's surface (10 cm/yr), as it is heated by the core. When the semi-molten rock reaches the base of the lithosphere it cools and solidifies creating new oceanic crust as; i.e. igneous rock. This process is known as ***sea floor spreading.*** The cooled rock then turns sideways and moves parallel to the earth's surface before descending back into the earth at ***subduction zones*** to become reheated.



Geologic Processes

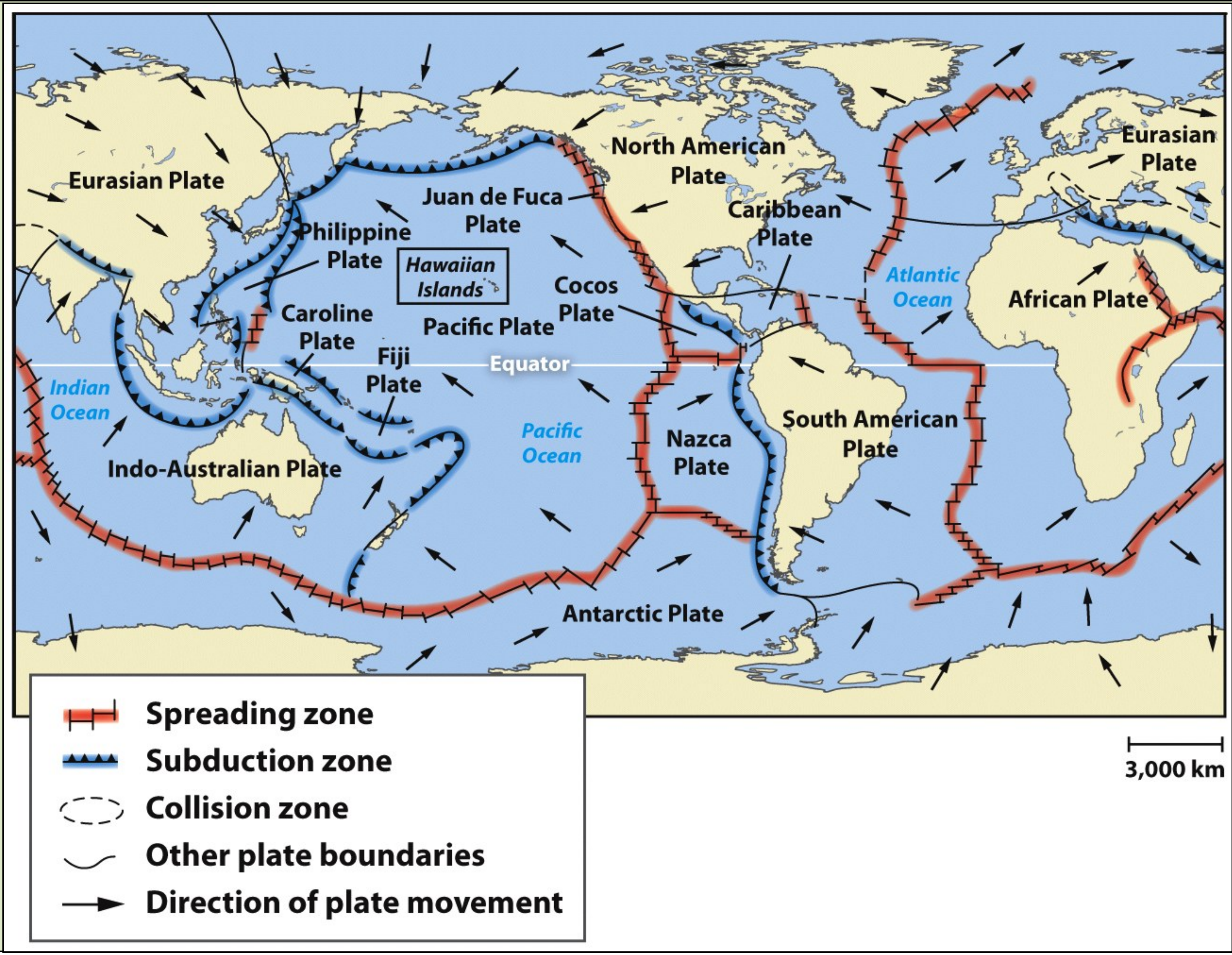
Convection Currents **provide the force that drives the movement of Earth's lithospheric plates.**





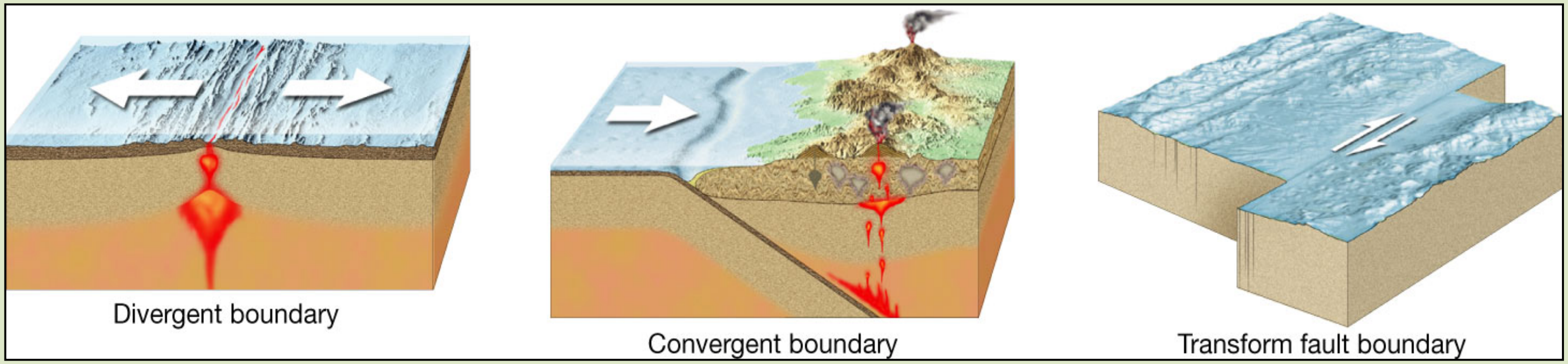
Spreading center
Oceanic tectonic plate
Oceanic tectonic plate
Oceanic tectonic plate
Tectonic plate
Ocean trench
Plate movement
Plate movement
Subduction zone
Oceanic crust
Oceanic crust
Continental crust
Continental crust
Material cools as it reaches the outer mantle
Cold dense material falls back through mantle
Mantle convection cell
Hot material rising through the mantle
Two plates move towards each other. One is subducted back into the mantle on a falling convection current.
Mantle
Hot outer core
Inner core

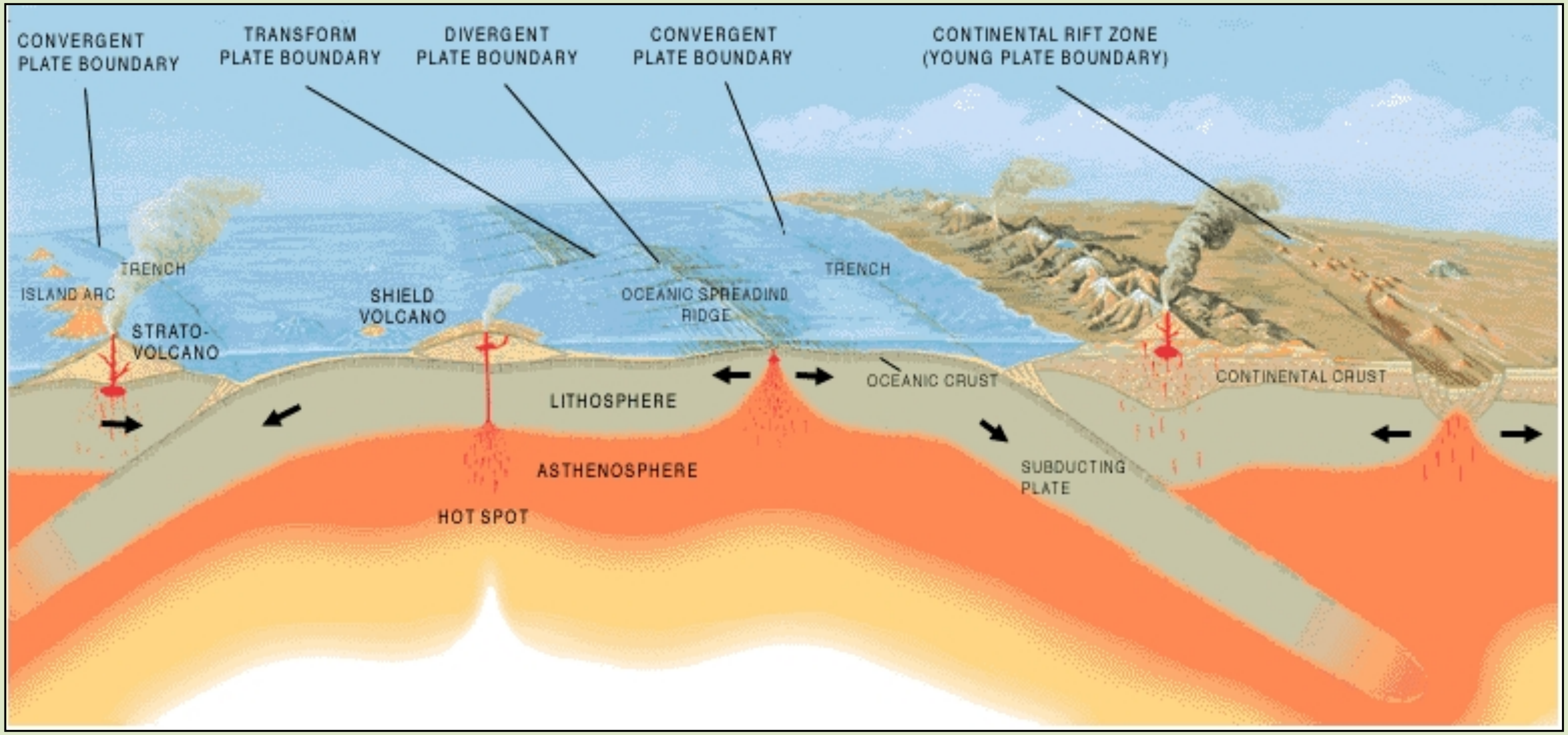
Geologic Processes



Geologic Processes

Plate boundaries: the area where two plates meet.





Geologic Processes

3 Types of Plate Boundaries

Divergent Boundary

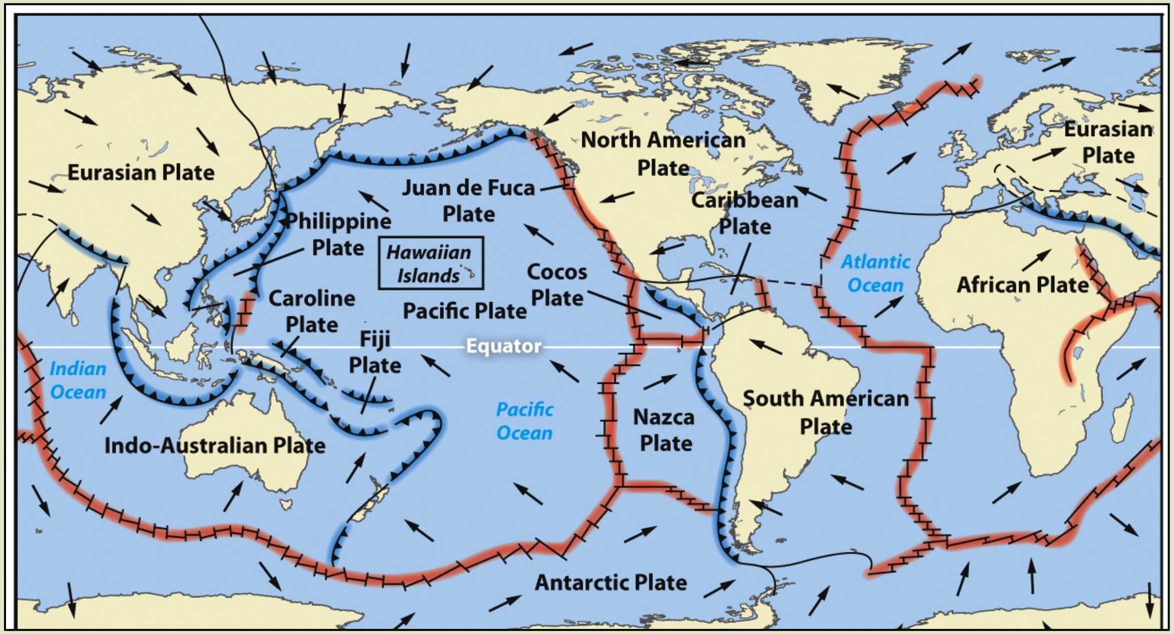
Two plates moving apart

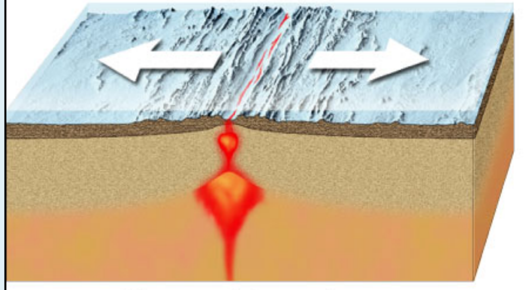
Convergent Boundary

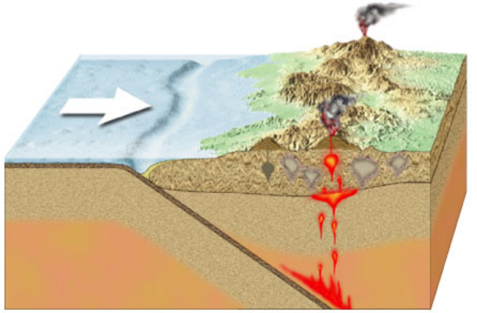
Two plates moving towards each other

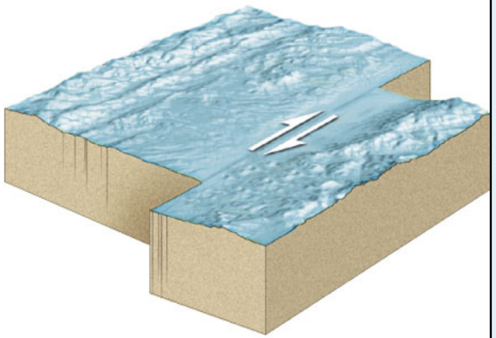
Transform Boundary

Two plates moving sideways past each other




Divergent boundary

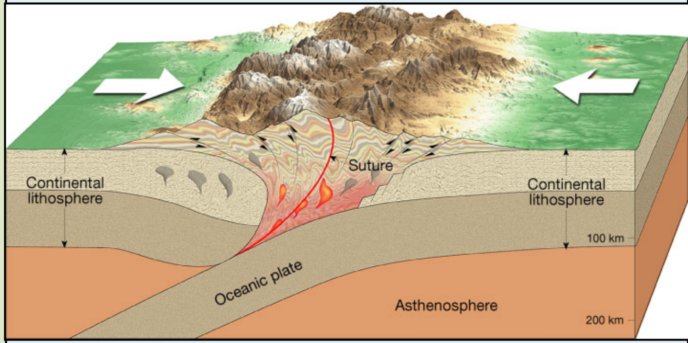

Convergent boundary


Transform fault boundary

3 Types of Convergent Plate Boundaries

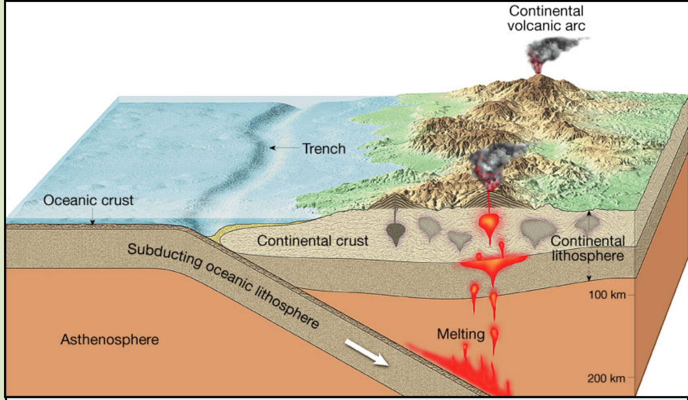
Continent-continent convergence

When two continental plates collide, mountain ranges are created as the colliding crust is compressed and pushed upward. Ex. Indian subcontinental plate being thrust under a portion of the Eurasian plate, lifting it and creating the mountains of the Himalaya. Powerful earthquakes are generated when stuck plates slip.



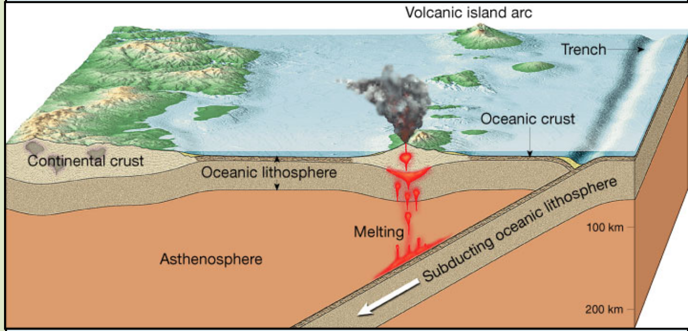
Ocean-continent convergence

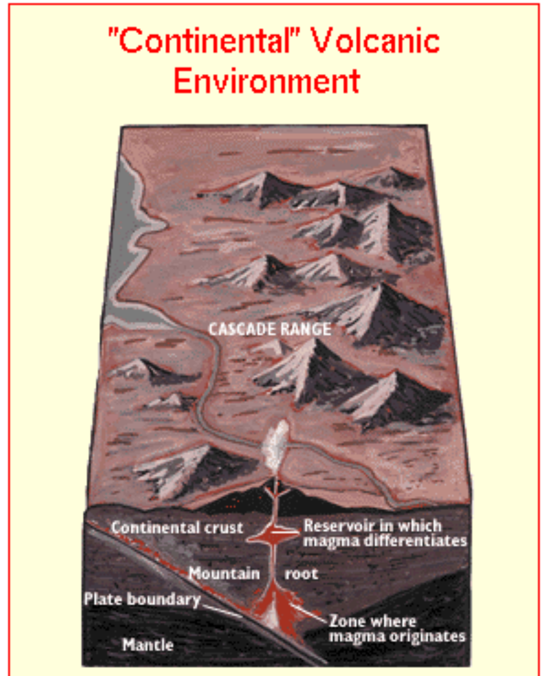
When a denser oceanic plate moves underneath a less-dense continental plate; creating a deep ocean trench and a subduction zone. The subducted plate melts and magma rises beneath the continental plate forming a continental volcanic arc; i.e. chain of volcanic mountains. Powerful earthquakes are generated when stuck plates slip, often creating Tsunami's.

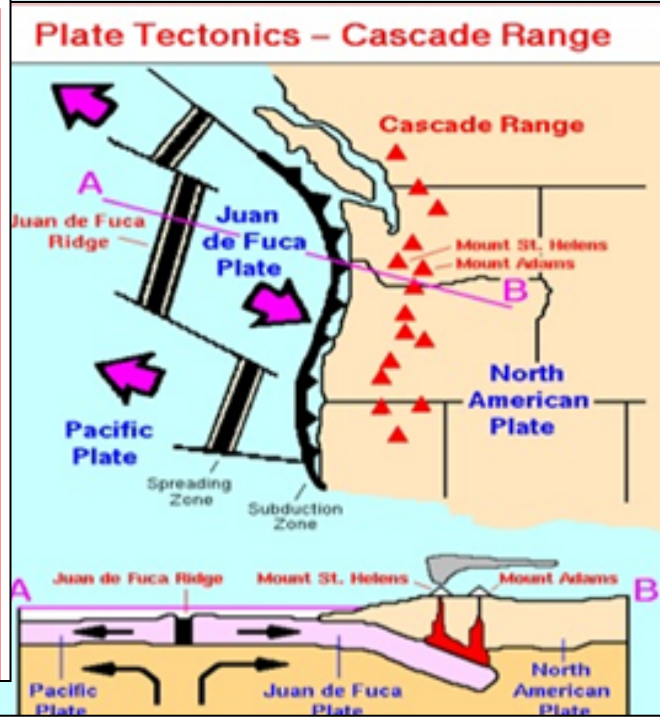


Ocean-ocean convergence

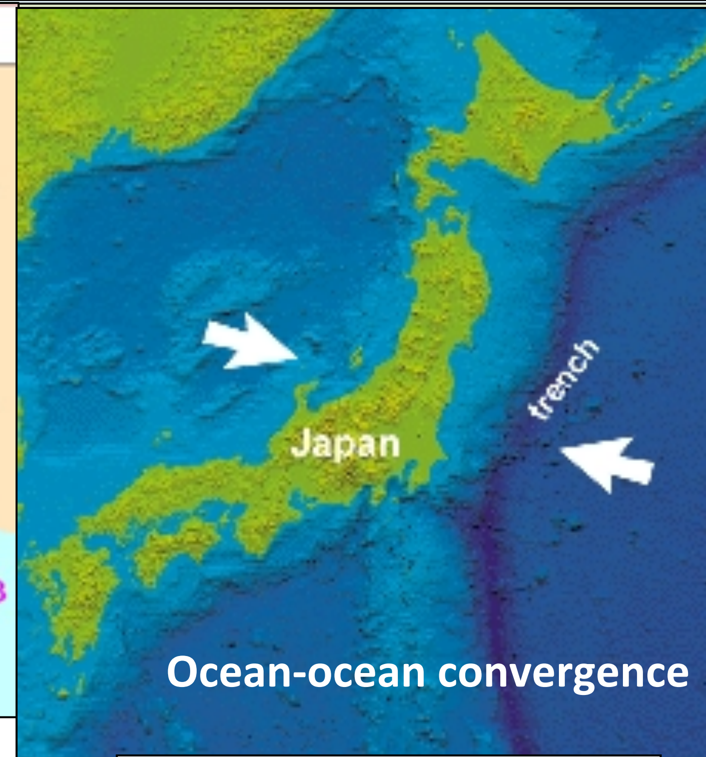
When two oceanic plates collide the denser of the two subducts. The subducted plate melts, magma rises creating a volcanic island arc; i.e. chain of volcanic islands. Powerful earthquakes are generated when stuck plates slip, often creating Tsunami's.



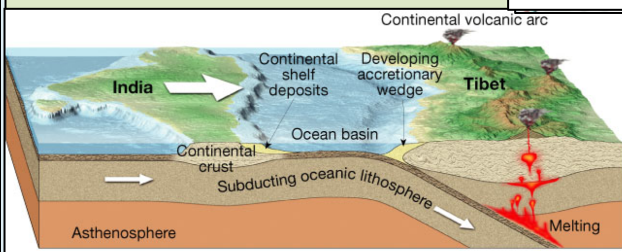




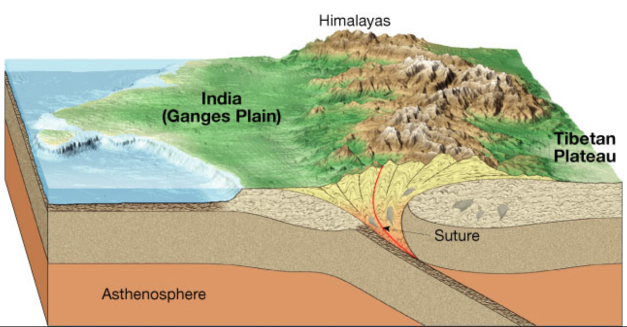
Ocean-continent convergence

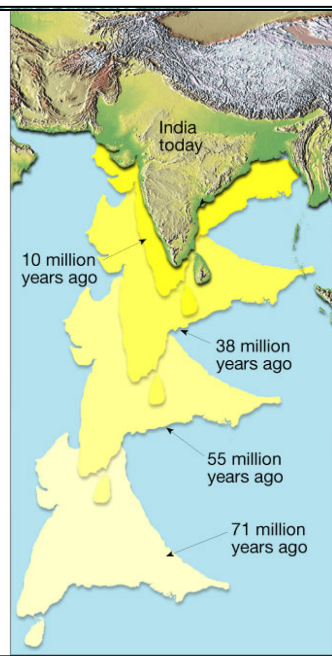


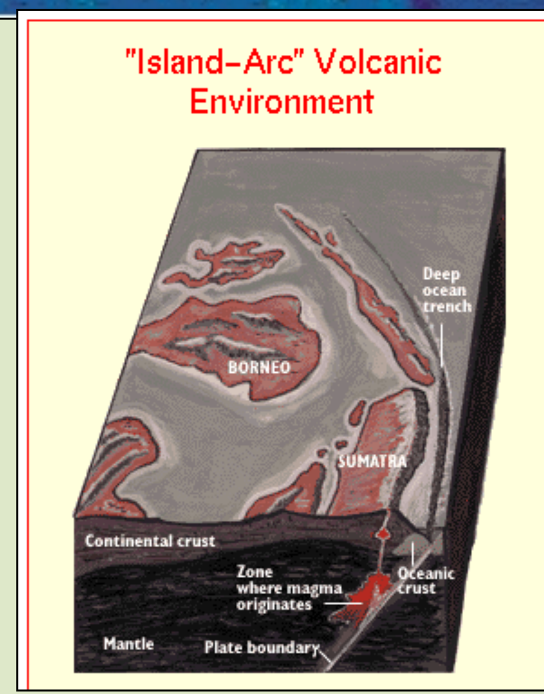
Ocean-ocean convergence

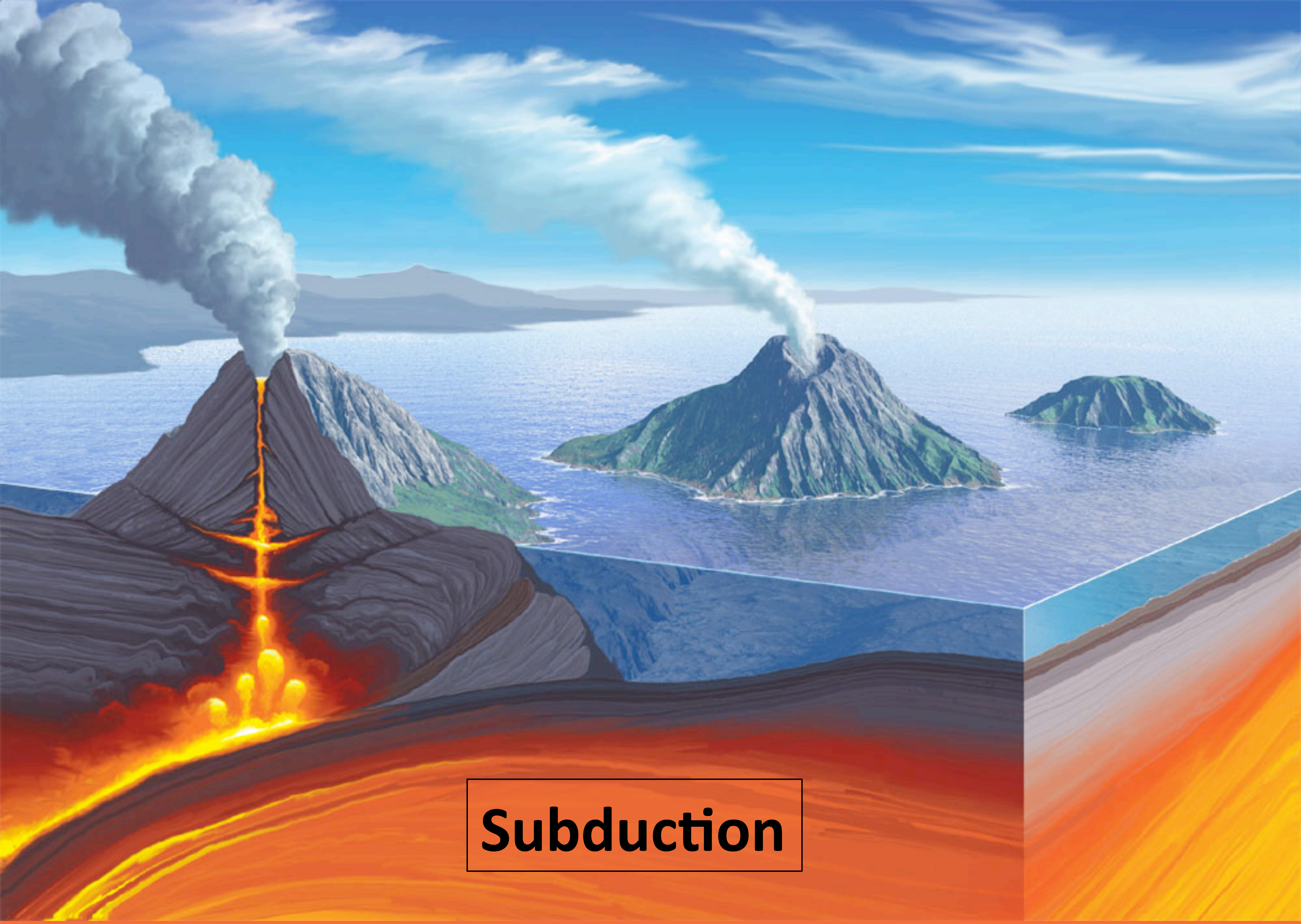


Continent-continent convergence





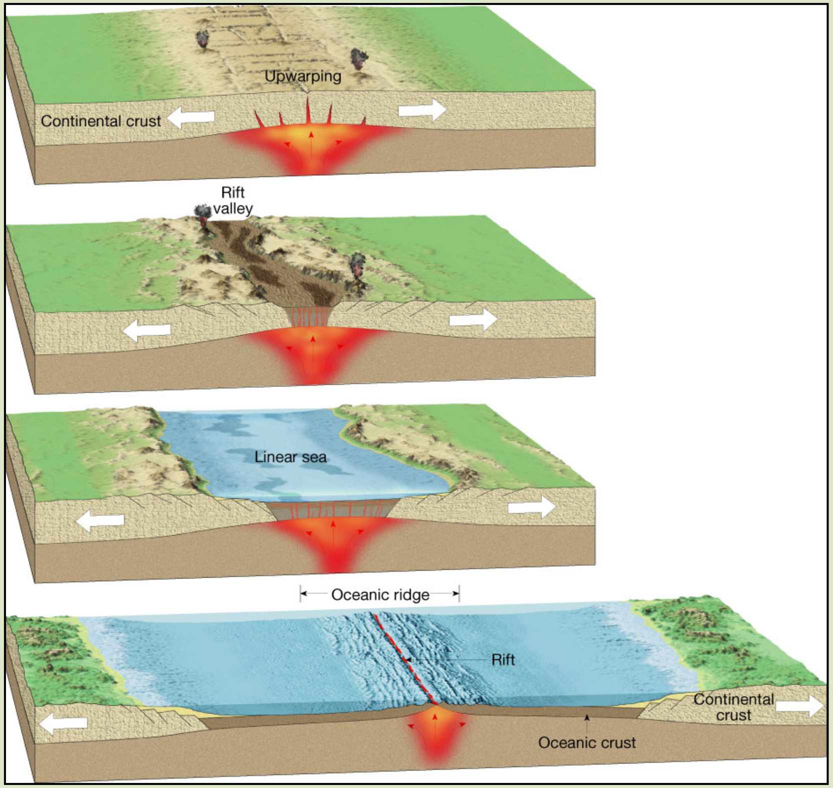


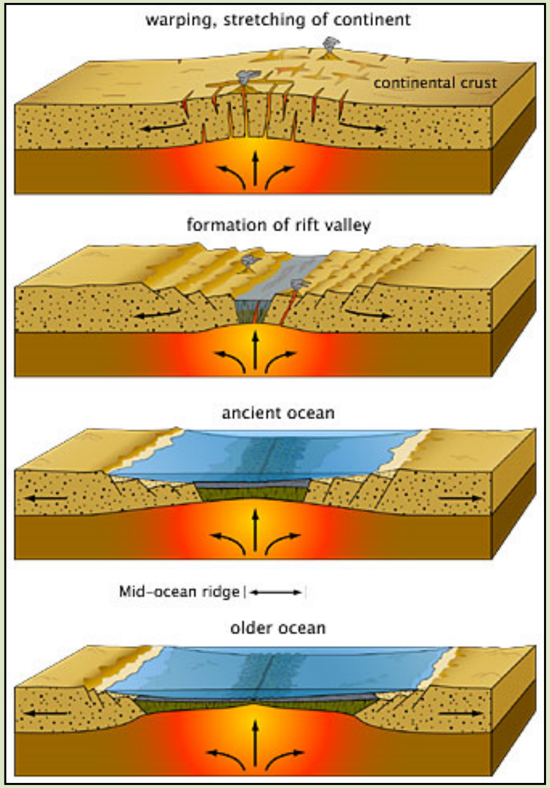

Subduction

Geologic Processes

Divergent Plate Boundary

When two plates move away from each other; rising magma from convection cells in the mantle exert pressure on Earth's crust causing rifting or cracks in the crust; molten rock or magma rising from convection fills in the cracks, cools and solidifies forming igneous rock, such as basalt. This slow, continual process results in the gradual expansion of the sea floor; i.e. ***Seafloor Spreading***.

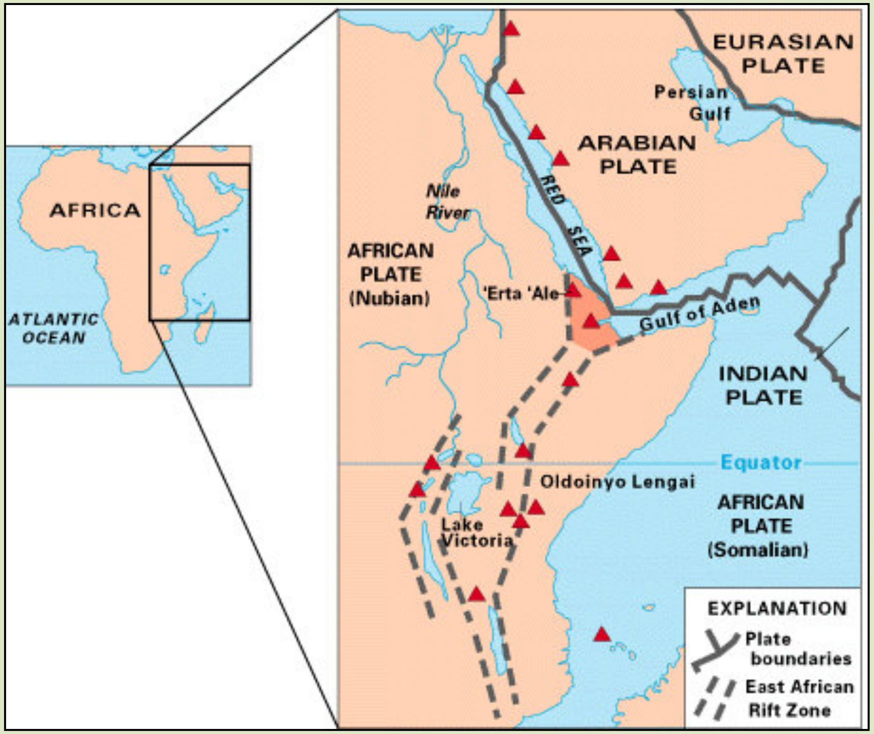




Geologic Processes

Divergent Plate Boundary

Examples of areas of oceanic divergent plate boundaries include the Mid-Atlantic Ridge and the East Pacific Rise (mid-ocean ridges). Examples of areas of continental divergent plate boundaries include the East African Great Rift Valley.

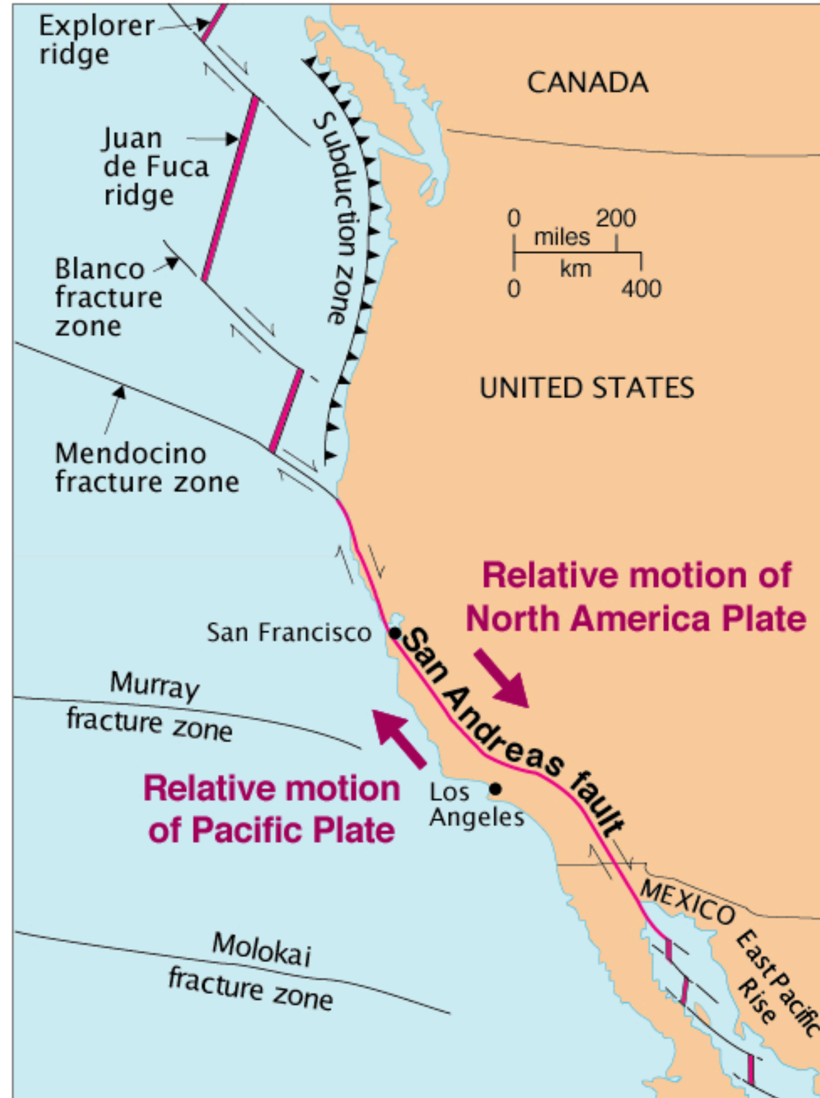


Geologic Processes

Transform Plate Boundary

When two plates slide sideways past each other. The San Andreas Fault, which is found near the western coast of North America, is where the Pacific and North American plates slide past each other.

The friction and stress buildup from the sliding plates frequently causes earthquakes.

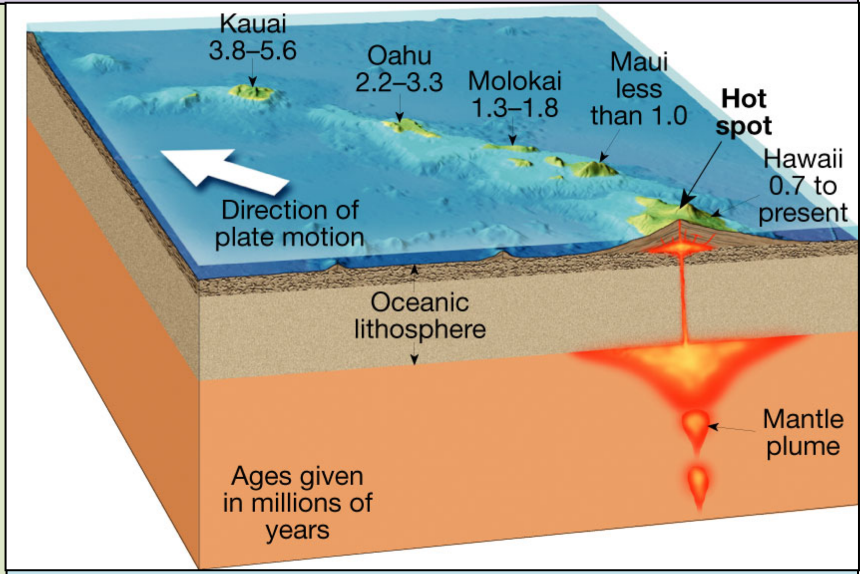


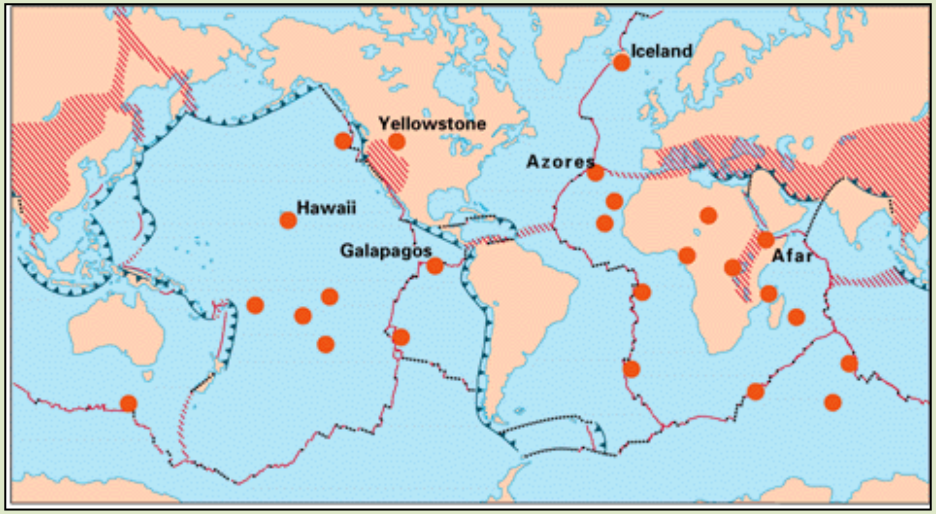
Geologic Processes

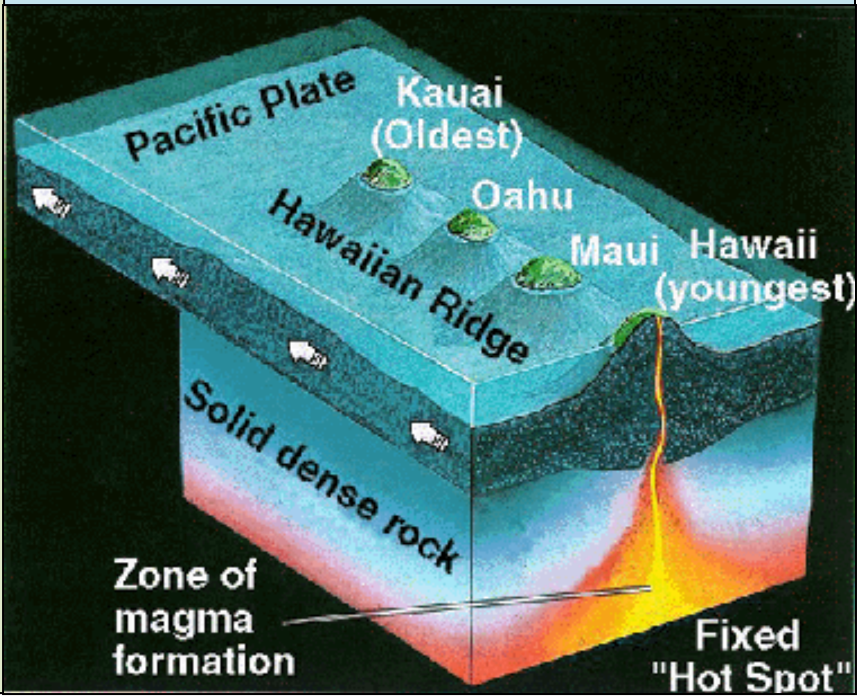
Hot Spots

Hot spots are located within the interior of lithospheric plates. Thus, they are not at plate boundaries. Earth's internal heat causes plumes of hot magma to well upward.

Hot spots are places where molten material from mantle asthenosphere reaches lithosphere. As plate moves over a hotspot, heat from mantle plume melts crust forming a volcano.







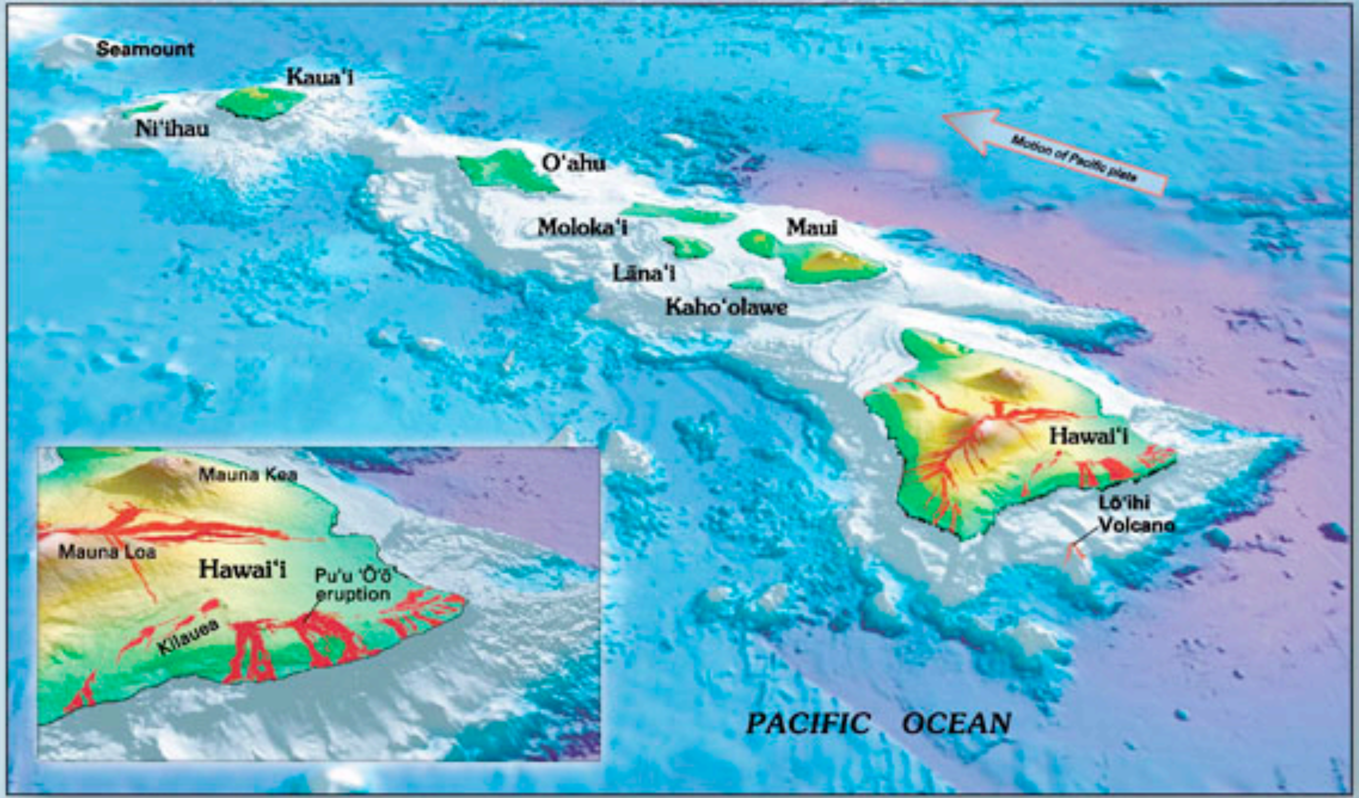
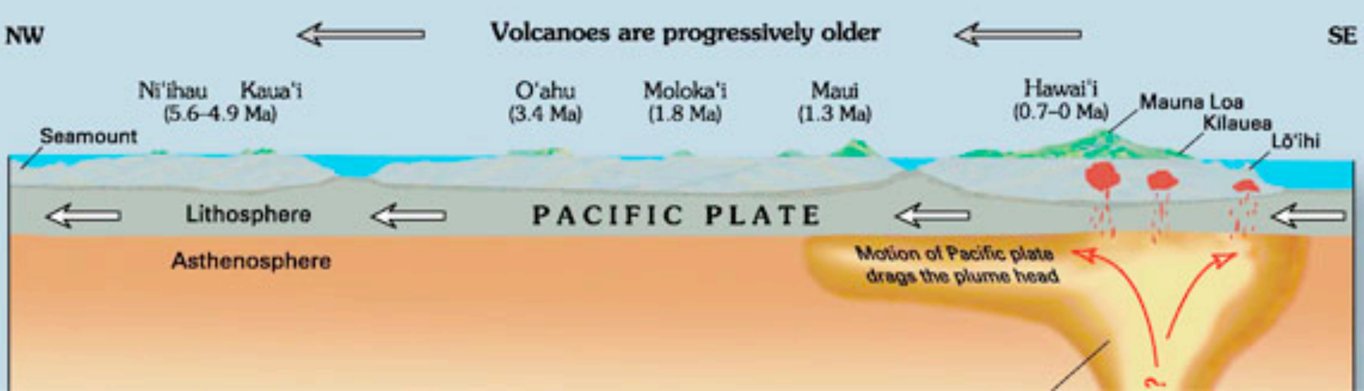
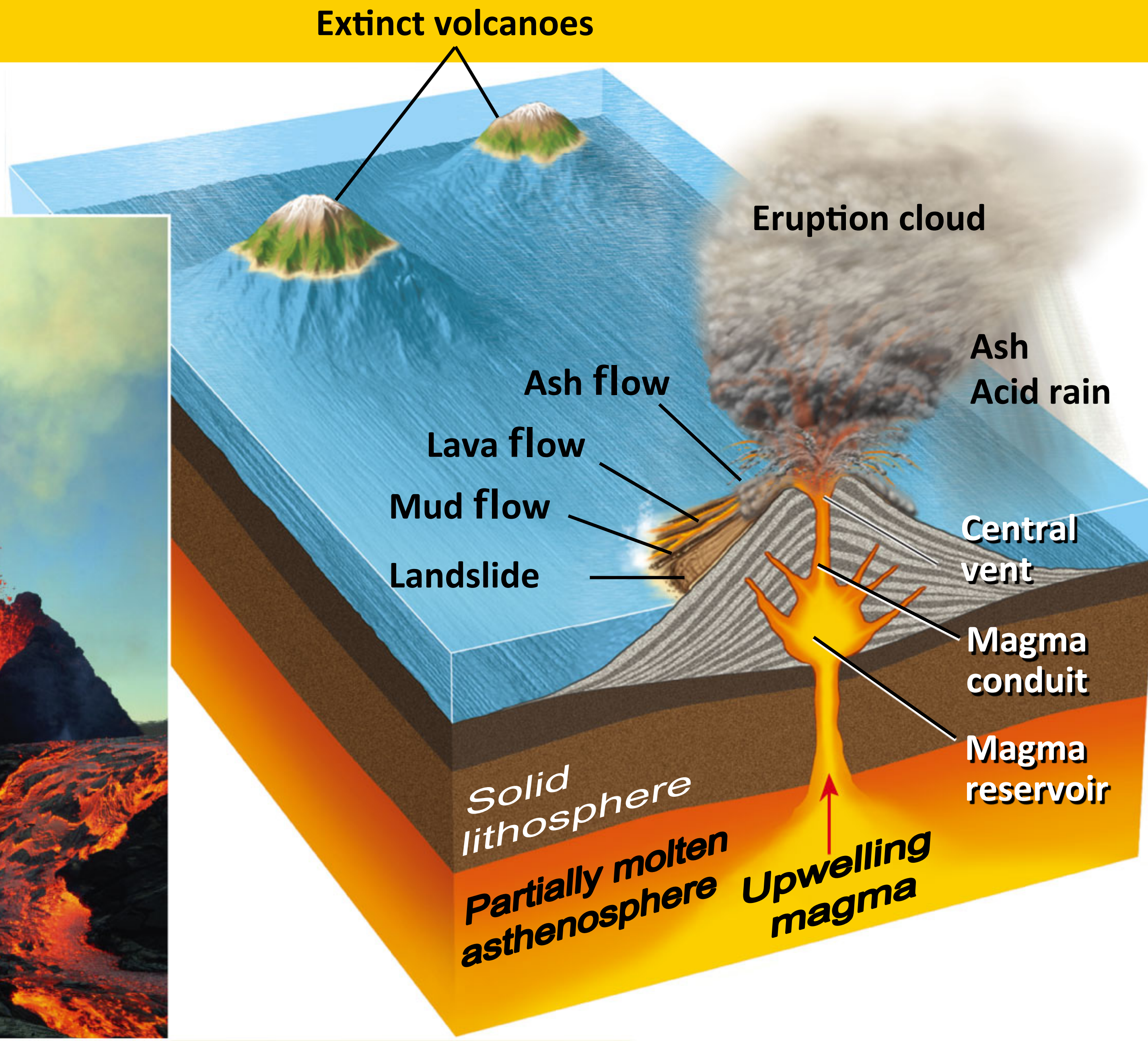


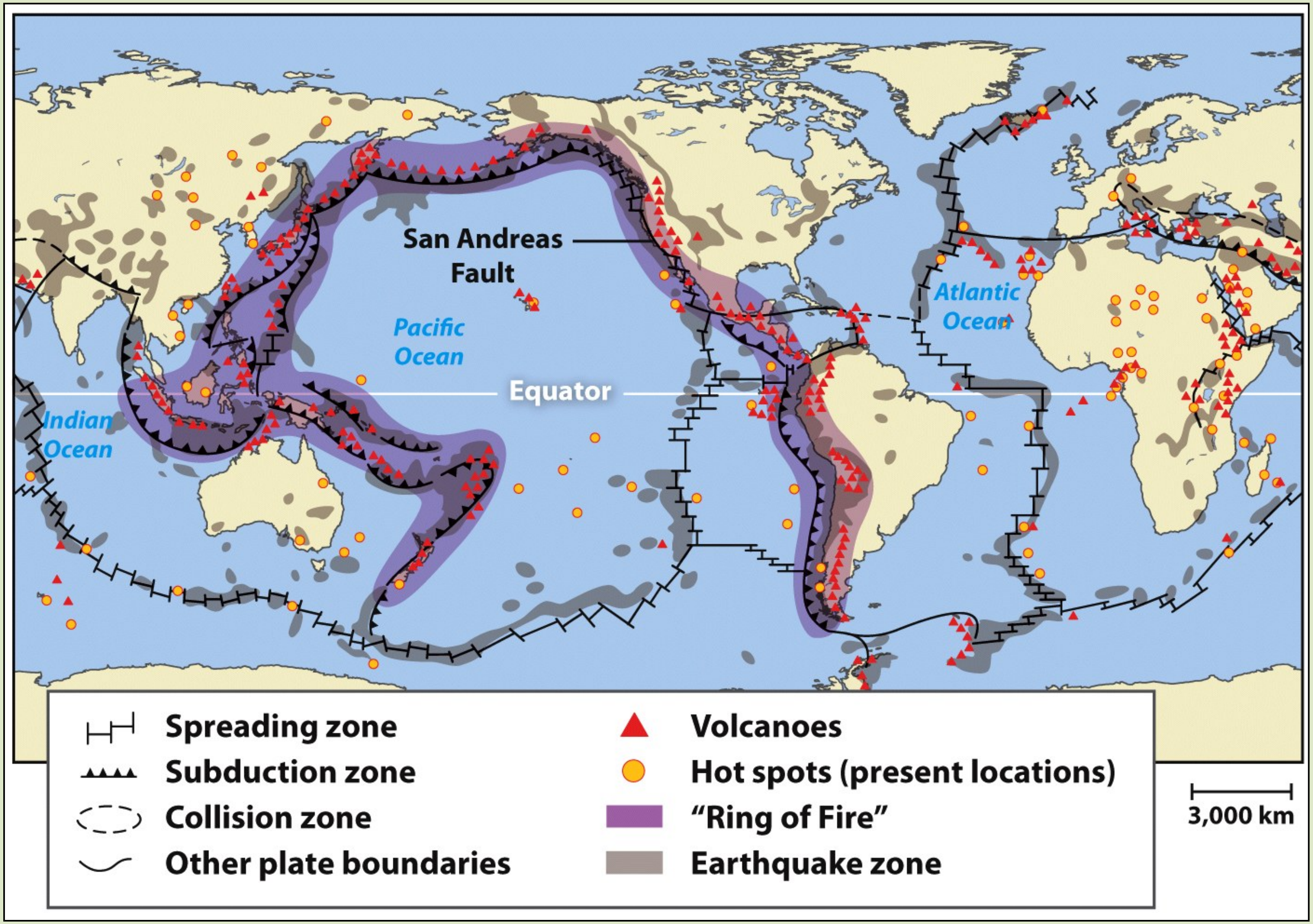
Figure 2.—Oblique view of the principal Hawaiian Islands and (the still submarine) Lō'ihi Volcano. Inset gives a closer view of three of the five volcanoes that form the Island of Hawai'i (historical lava flows are shown in red). The longest duration historical eruption on Kīlauea's east-rift zone at Pu'u 'Ō'ō (inset), which began in January 1983, continues unabated (as of spring 2006). View prepared by Joel E. Robinson (USGS).



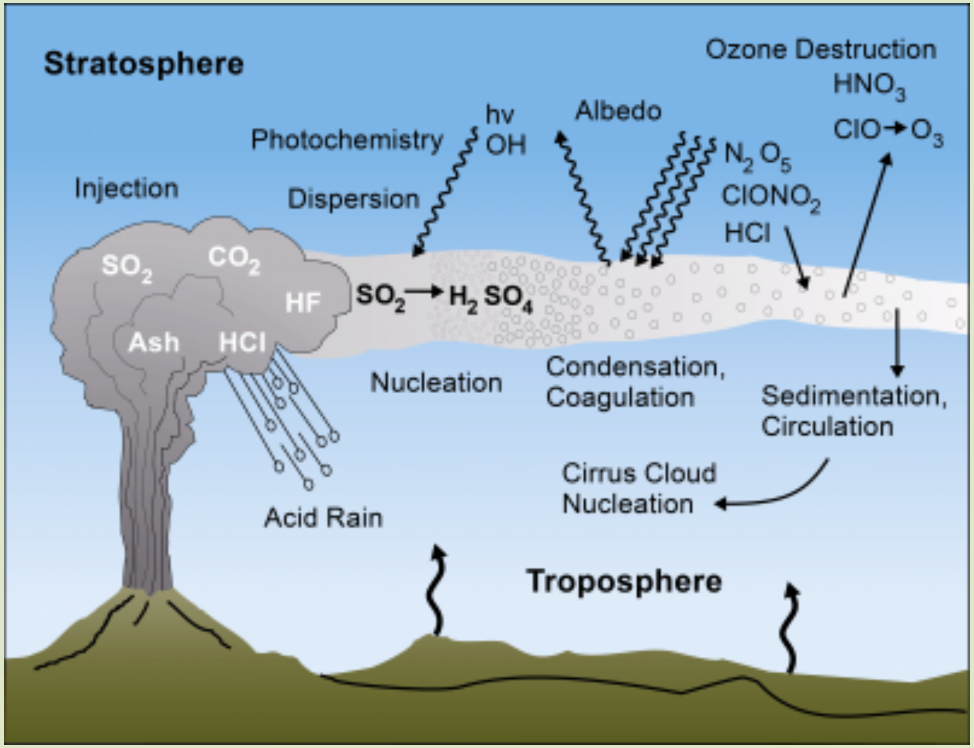

Extinct volcanoes
Eruption cloud
Ash
Acid rain
Ash flow
Lava flow
Mud flow
Landslide
Central vent
Magma conduit
Magma reservoir
Solid lithosphere
Partially molten asthenosphere
Upwelling magma

Volcanoes

Active volcanoes produce magma (molten rock) and lava at the surface. The majority of volcanoes—95%—occur at ***subduction zones*** and ***mid-ocean ridges***. The remaining 5% occur at ***hotspots***.



Volcanic Gases & Global Climate- In addition to ejecting lava and rocks, volcanoes also eject ash and release gases into the atmosphere. The most common gases released by volcanoes are steam, carbon dioxide, sulfur dioxide, and hydrogen chloride. Volcanoes affect the climate by releasing large quantities of sulfur dioxide (SO_2) into the atmosphere that is later converted into sulfate ions in the stratosphere (SO_4^{2-}). These sulfate particles reflect solar radiation and serve as condensation nuclei for high clouds, resulting in increased albedo, i.e. reflection of solar radiation back to space. The net result is global cooling. In 1992, the year after the Mt. Pinatubo eruption in the Philippines, the effect of stratospheric sulfate particles decreased the average global temperature by 1°F.



Geologic Processes

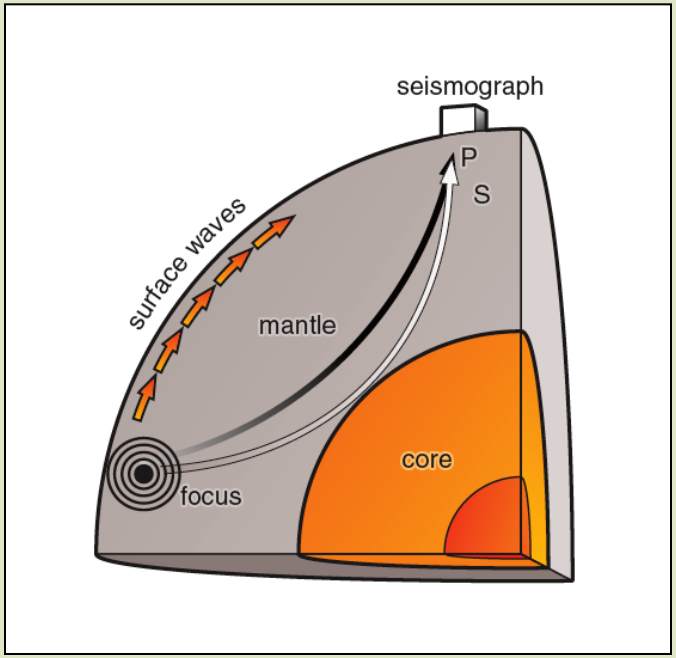
Earthquakes

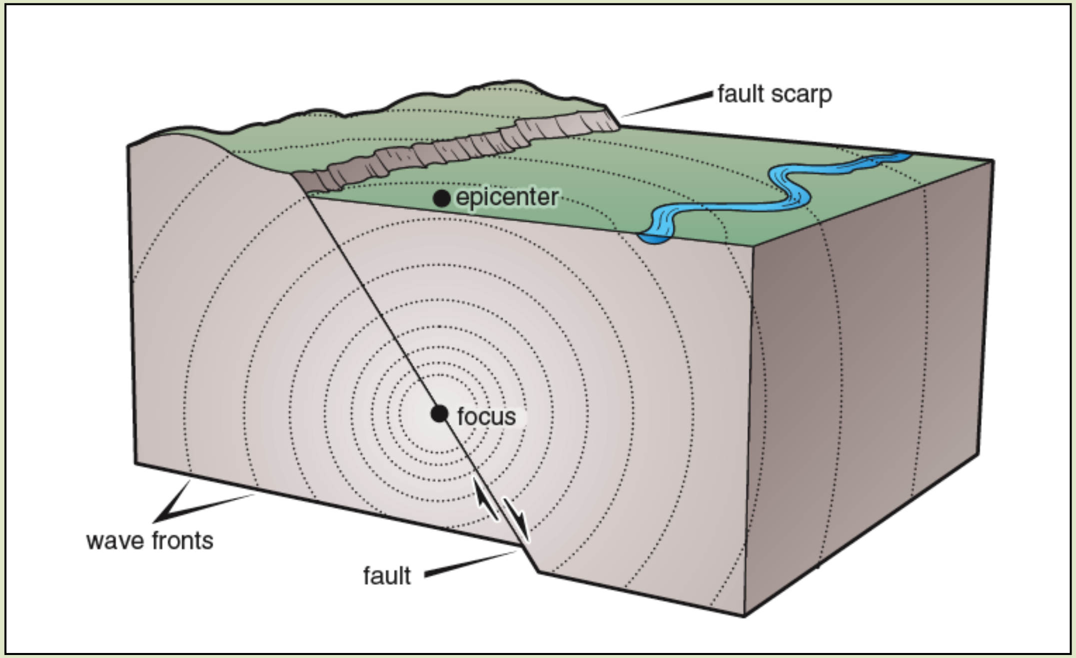
Earthquakes occur during abrupt movement on an existing fault, along tectonic plate boundary zones or along mid-ocean ridges.

Seismic Waves: energy is released during earthquakes in the form of seismic waves.

Focus: the place in the Earth along the fault where rupture occurs

Epicenter: the geographic point on the surface directly above the focus

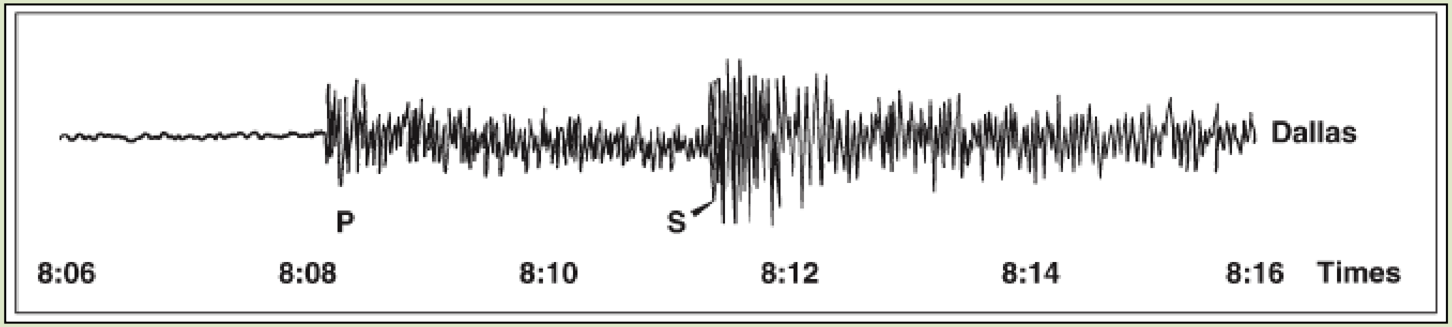




<u>**Earthquakes**</u>

Seismometer: an instrument used to measure seismic waves

Seismograph: the record of earthquake vibrations made by a seismometer

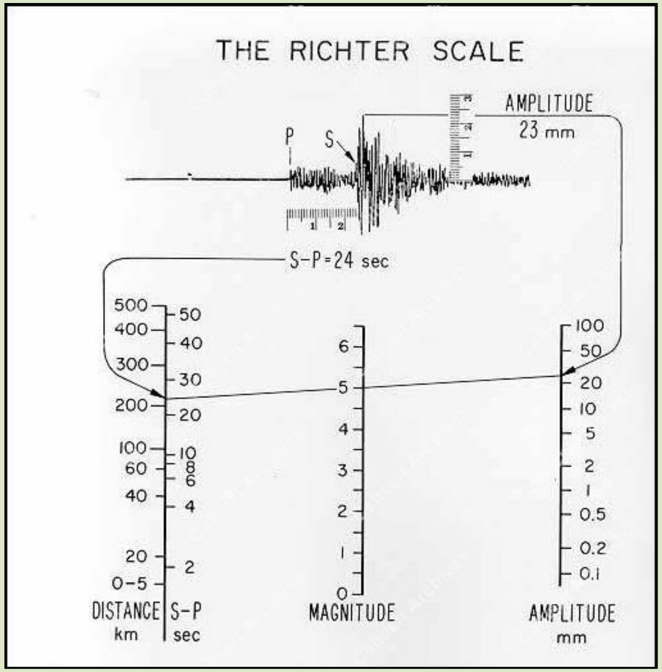


P-waves travel fastest through the Earth so they arrive first at a distant seismograph station. S-waves arrive shortly after.

The Richter scale: The strength or magnitude of an earthquake is commonly measured by the logarithmic Richter scale.

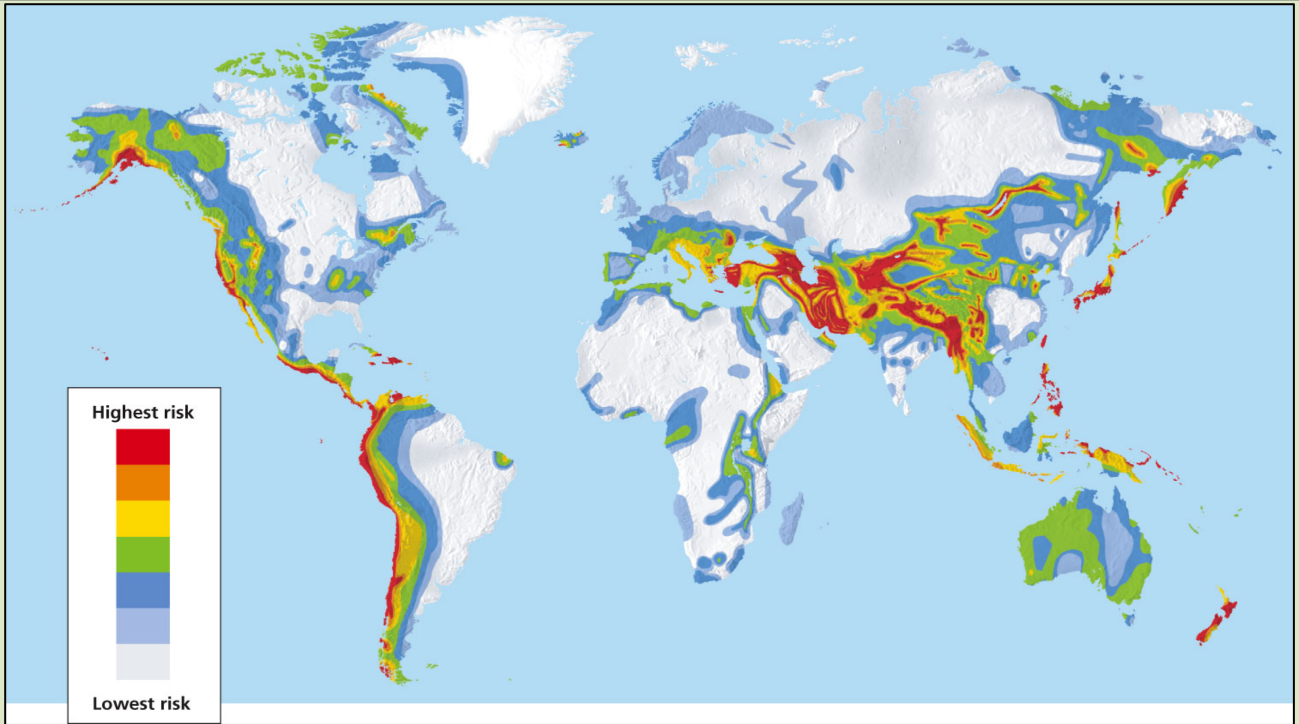
Amplitude: Essentially, the measure of the height of the wave from it's rest position; basically half of the wave.

Magnitude: Earthquake magnitude, using the Richter scale, is a measure of the amplitude of the largest seismic wave recorded on a seismogram.



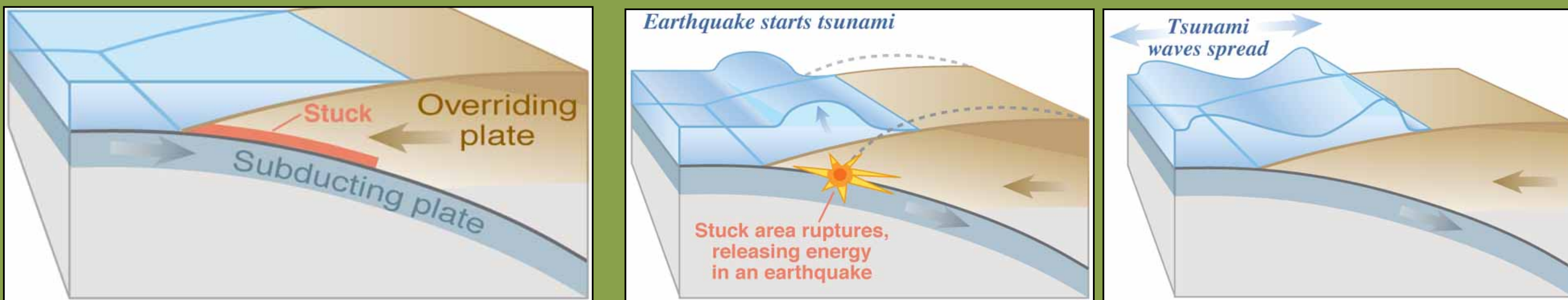
<u>Earthquakes</u>- Richter Scale & World Earthquake Risk

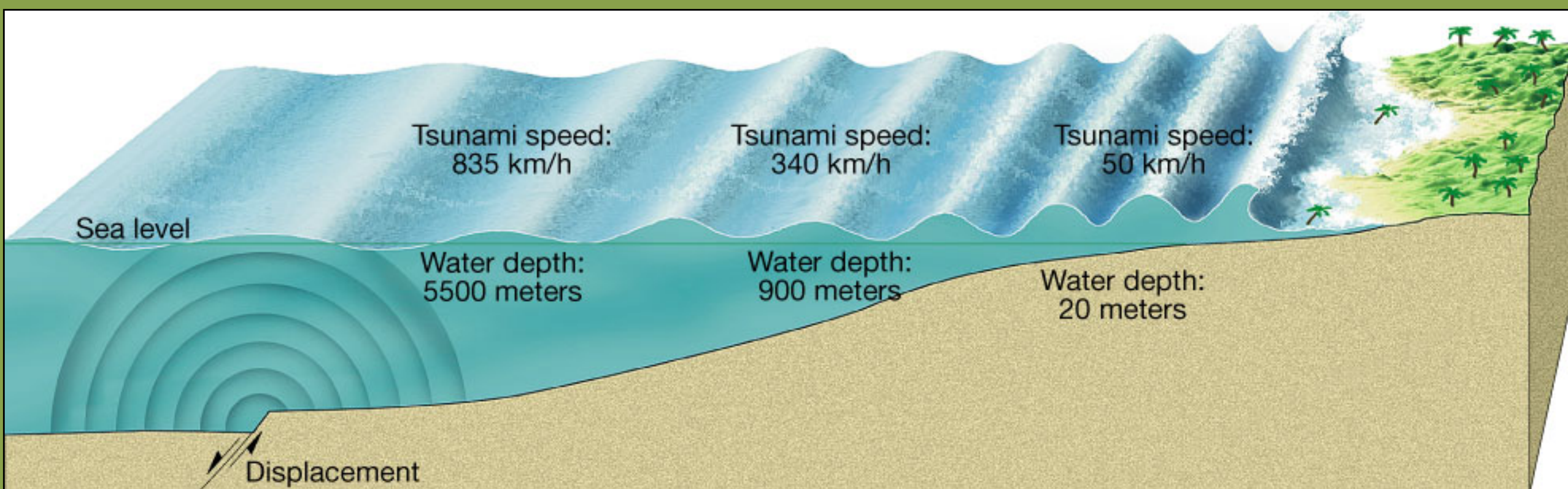
Magnitude	Description	Earthquake effects	Frequency of occurrence
Less than 2.0	Micro	Micro earthquakes, not felt.[15]	Continual
2.0–2.9	Minor	Generally not felt, but recorded.	1,300,000 per year (est.)
3.0–3.9		Often felt, but rarely causes damage.	130,000 per year (est.)
4.0–4.9	Light	Noticeable shaking of indoor items, rattling noises. Significant damage unlikely.	13,000 per year (est.)
5.0–5.9	Moderate	Can cause major damage to poorly constructed buildings over small regions. At most slight damage to well-designed buildings.	1,319 per year
6.0–6.9	Strong	Can be destructive in areas up to about 160 kilometres (99 mi) across in populated areas.	134 per year
7.0–7.9	Major	Can cause serious damage over larger areas.	15 per year
8.0–8.9	Great	Can cause serious damage in areas several hundred kilometres across.	1 per year
9.0–9.9		Devastating in areas several thousand kilometres across.	1 per 10 years (est.)
10.0+	Massive	Never recorded, widespread devastation across very large areas; see below for equivalent seismic energy yield.	Extremely rare (Unknown/May not be possible)



Earthquakes- Tsunami

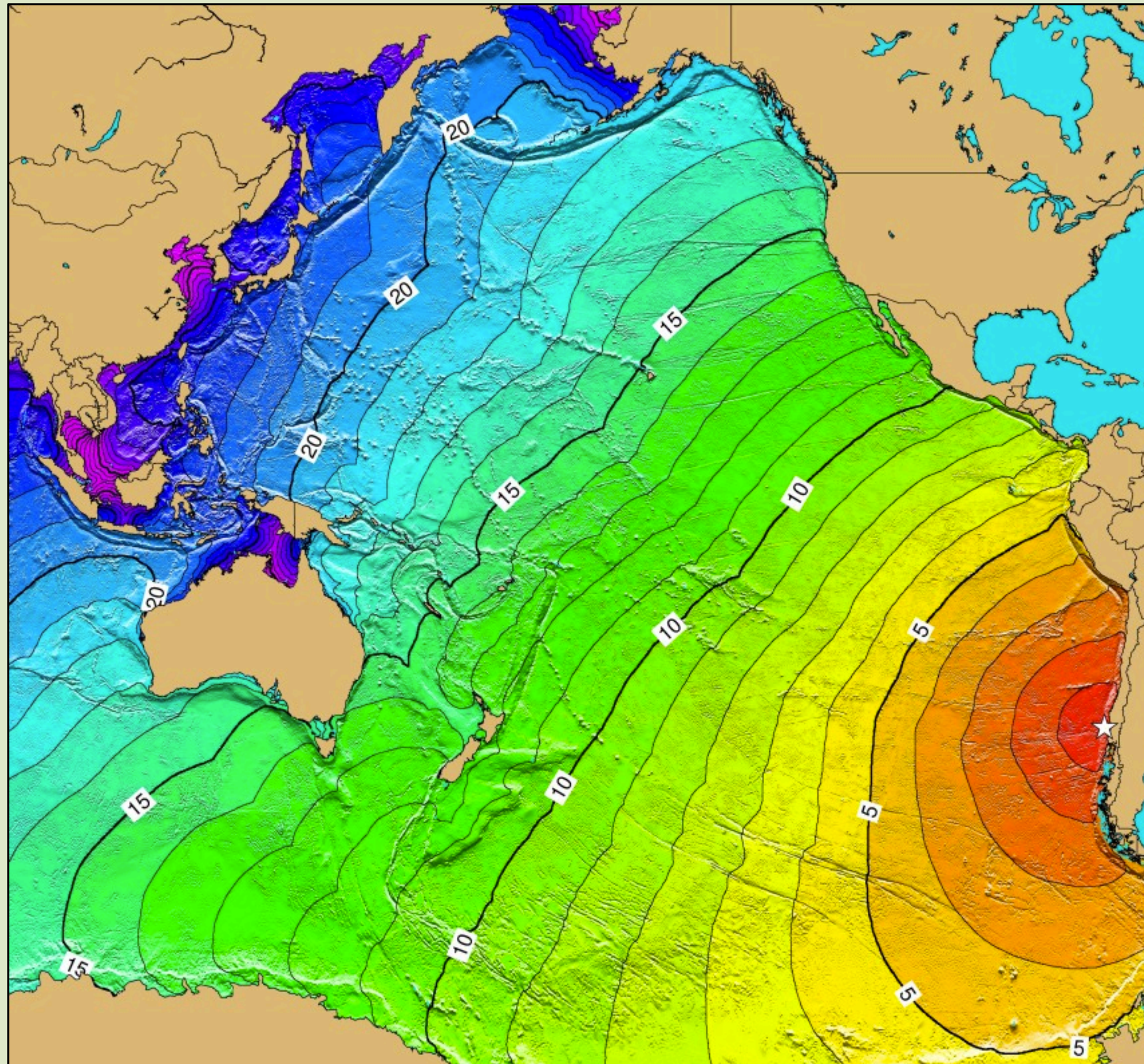
Largest recorded earthquake: 9.5 in Chile in 1960. It is referred to as the "Great Chilean Earthquake" and the "1960 Valdivia Earthquake”. Most of the damage and deaths were caused by a series of tsunamis that were generated by the earthquake.





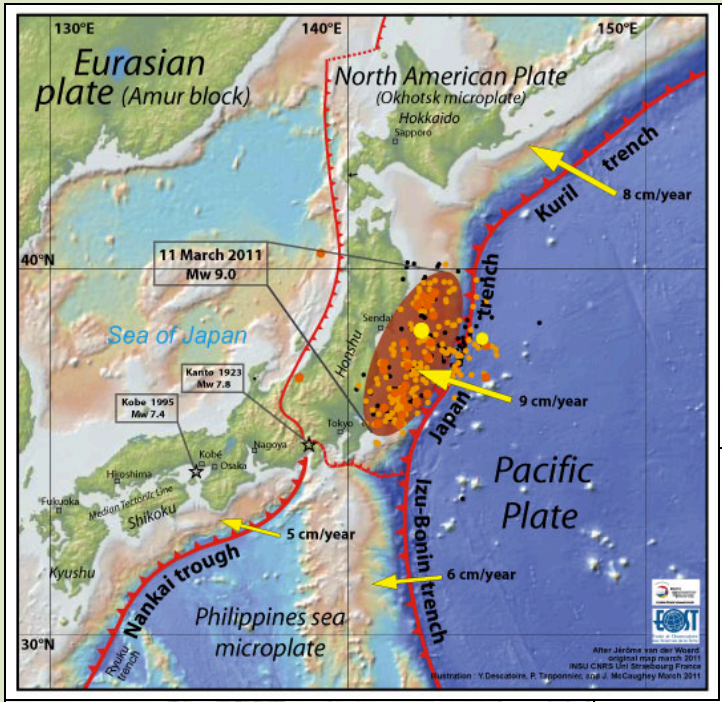
Earthquakes & Tsunami's

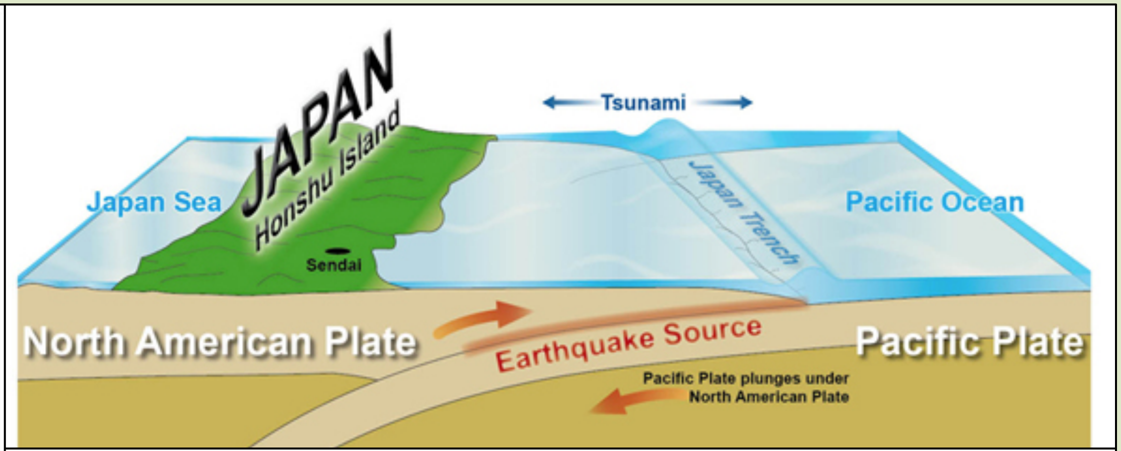
Tsunami distribution of the 1960 "Great Chilean Earthquake". The star marks the location of the epicenter, and the numbers on the contour lines are travel times in hours for the wave front.

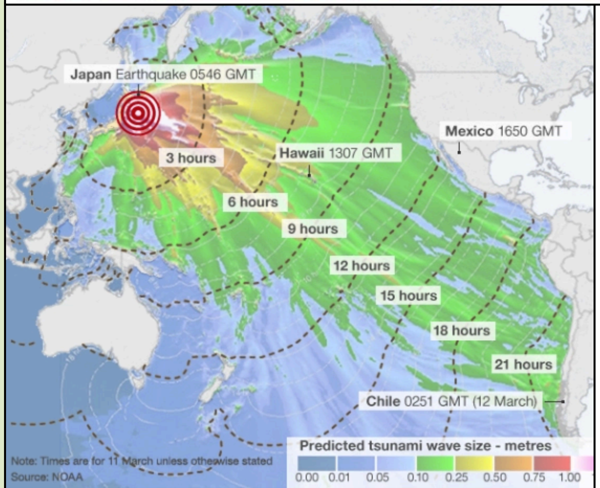


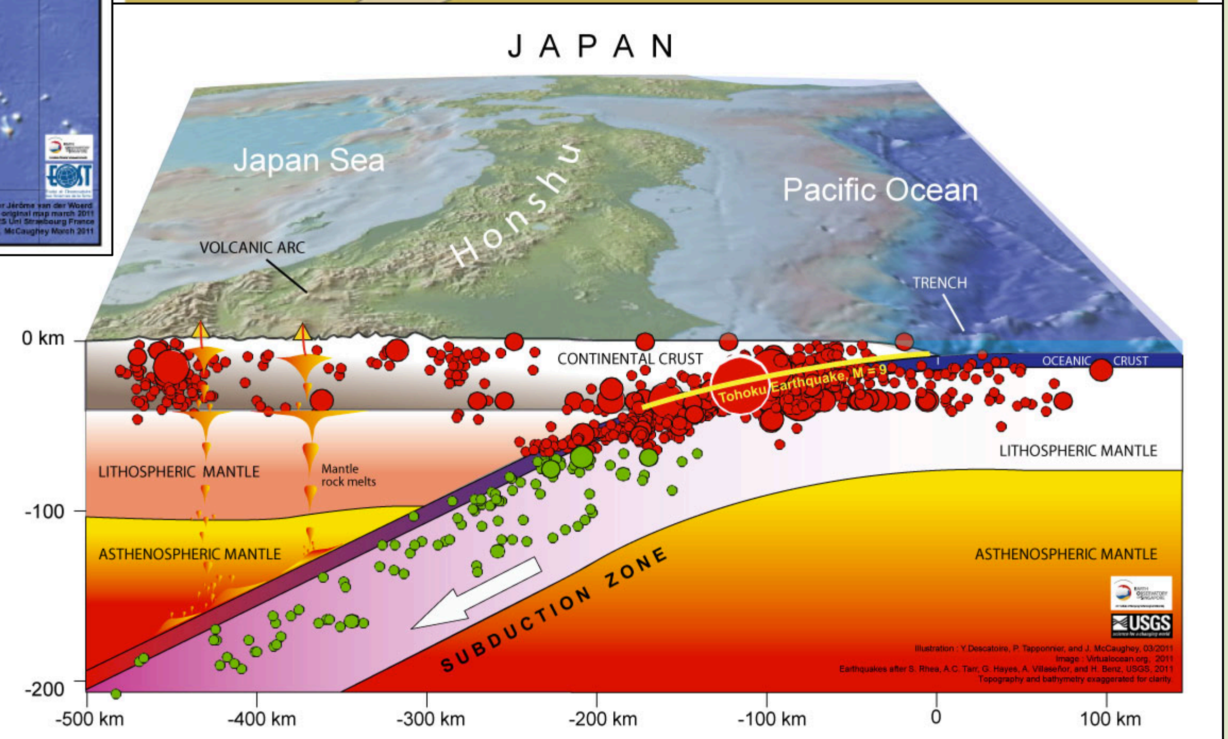
Tōhoku Earthquake & Tsunami

On March 11, 2011 northern Japan was hit by a 9.0 magnitude earthquake that triggered a deadly 23-foot Tsunami.



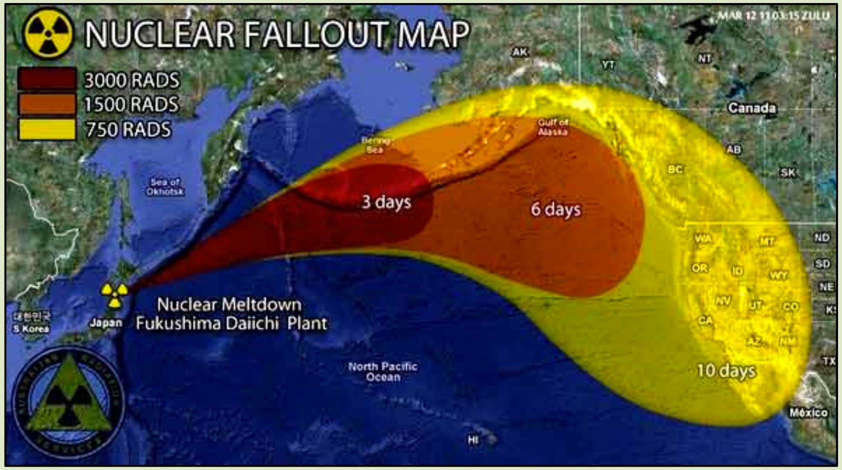






Tōhoku Earthquake & Tsunami

Northern Japan's coastal Fukishima Daiichi nuclear power plant suffered catastrophic damage from the tsunami. Cooling systems failed causing a nuclear reactor failure, followed by an explosion and partial meltdown in the nuclear reactors. This released radiation into the ocean and the atmosphere. This disaster is considered one of the worst nuclear disasters of all time; on par with Chernobyl's nuclear reactor explosion in 1986.



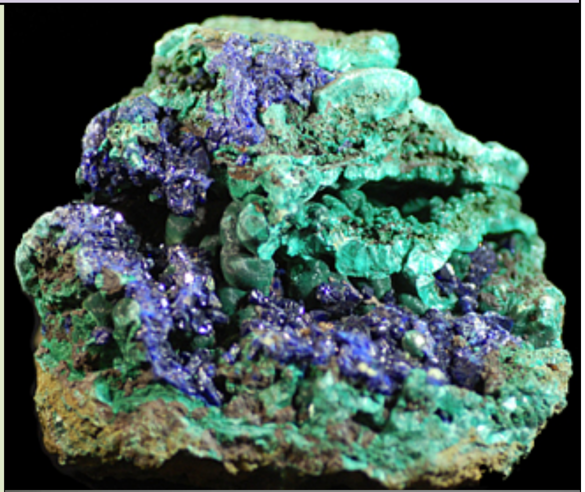
Geologic Processes

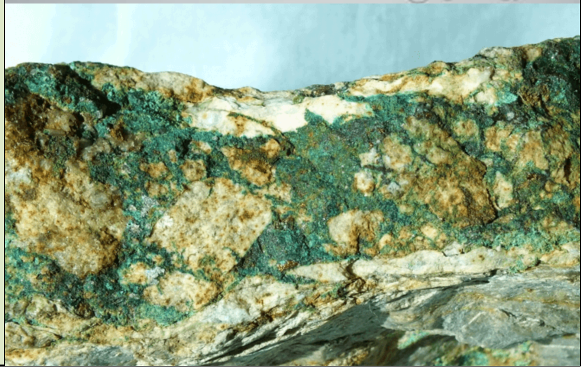
The Rock Cycle

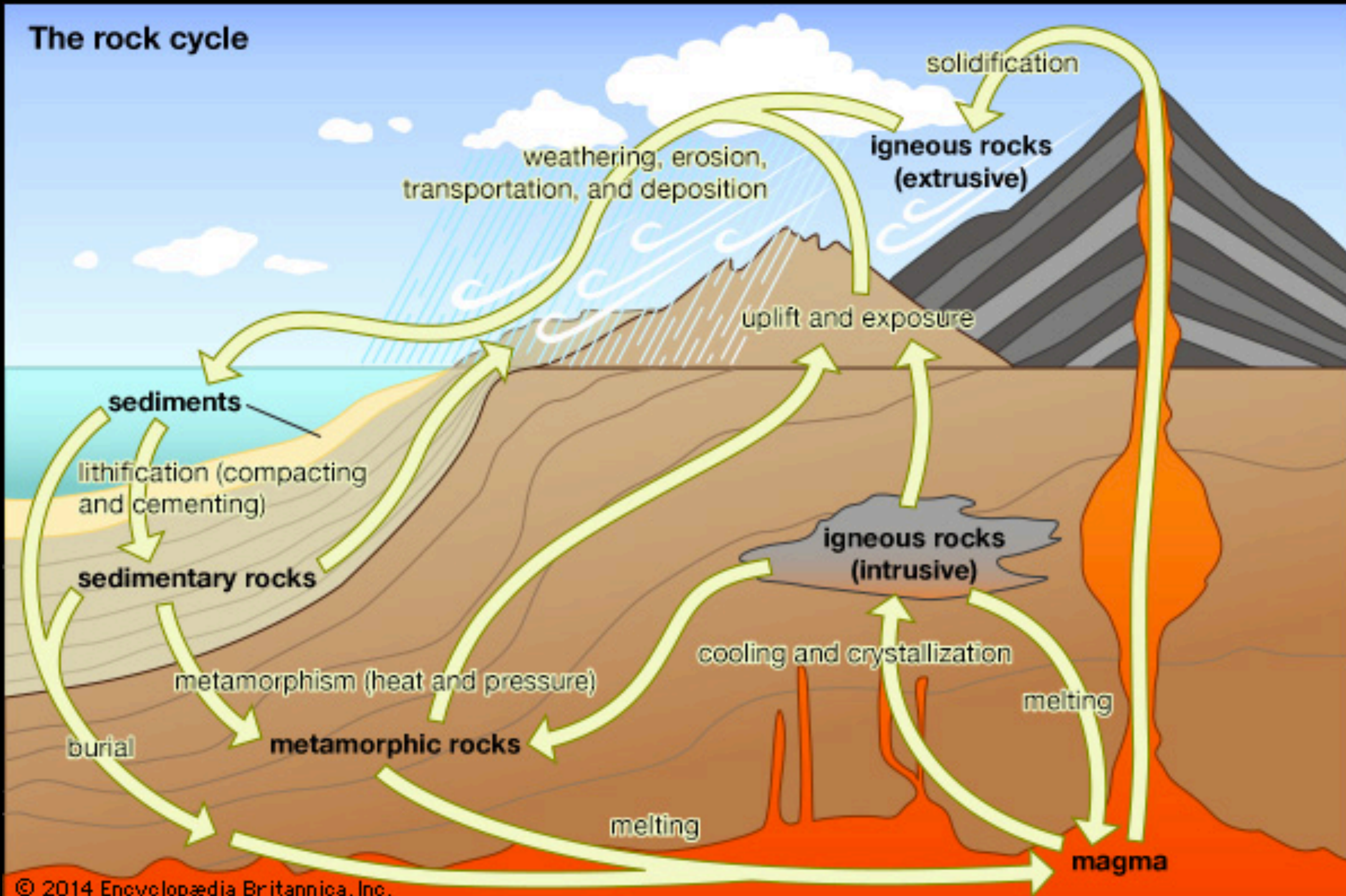
Mineral: element or inorganic compound that occurs naturally, is solid with a crystalline structure. Au, Ag, diamond (C), quartz (SiO_2)

Rock: any material that makes up a large, natural, continuous part of the Earth's crust. May be composed of a single mineral type (limestone-$CaCO_3$) but most are two or more minerals (granite-feldspar, quartz, mica)

Ore: a rock that contains a large enough concentration of a mineral-often a metal-that it can be mined and processes to extract the mineral.

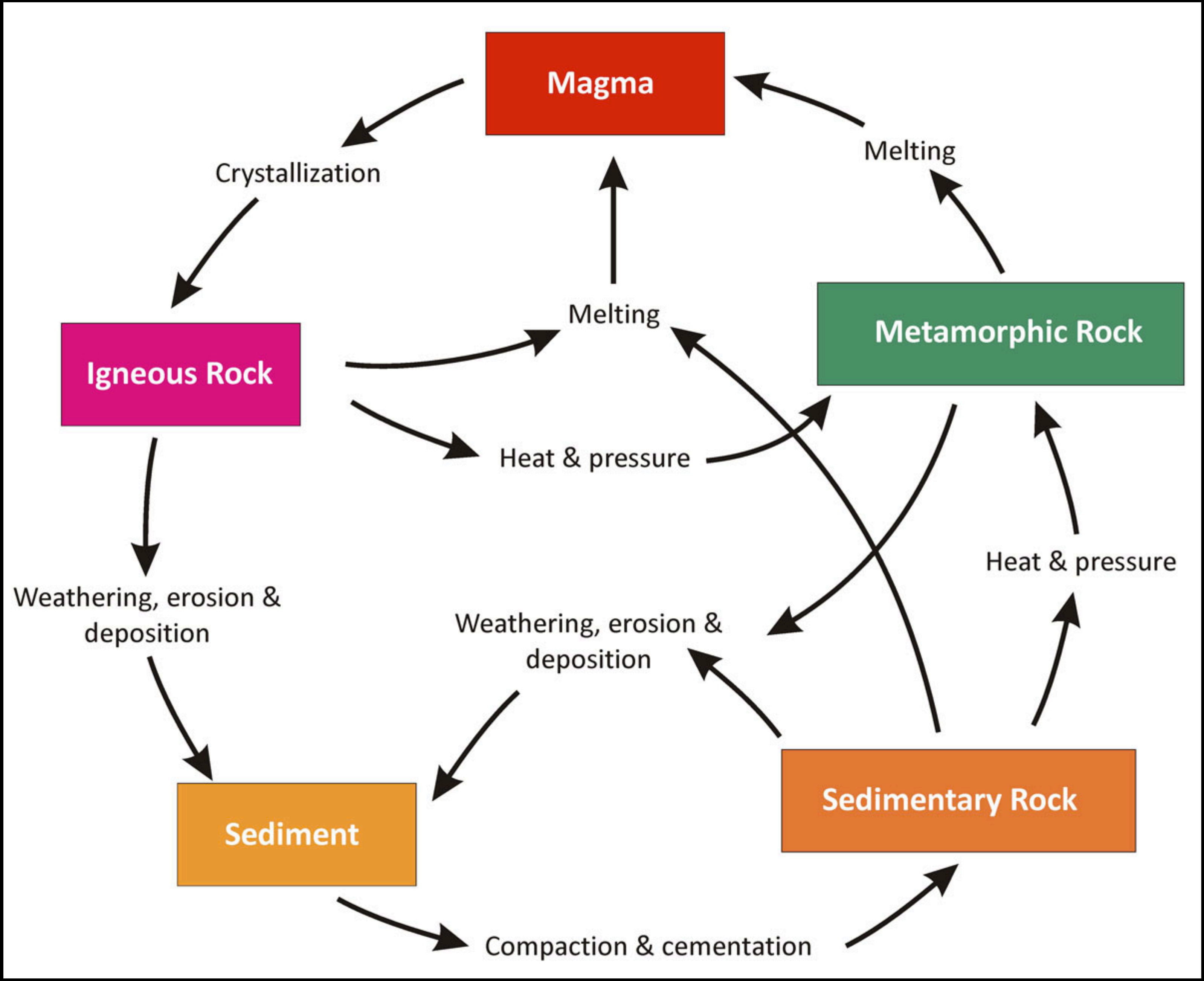






The rock cycle
solidification
igneous rocks
(extrusive)
weathering, erosion,
transportation, and deposition
uplift and exposure
sediments
lithification (compacting
and cementing)
sedimentary rocks
igneous rocks
(intrusive)
cooling and crystallization
metamorphism (heat and pressure)
melting
burial
metamorphic rocks
melting
magma

The Rock Cycle



Geologic Processes

<u>The Rock Cycle: Three Major Types of Rocks</u>

Sedimentary

Sediments from existing rocks are broken down by *weathering* and *erosion*; transported by water, wind, gravity; deposited in layers in the bottom of lakes, rivers, and oceans (river delta & continental shelf) where they are *compacted* and *cemented* to form solid rock; Or plant material is compressed through deep burial; or shells from marine organisms are deposited on the ocean floor and compacted.

Ex. Sandstone, Limestone, coal

Igneous

Magma within the earth *cools* slowly (intrusive) or lava on Earth's surface *cools* quickly (extrusive), **minerals** *crystallize* and *solidify* to form igneous rock.

Ex. Granite (intrusive), basalt (extrusive)

Metamorphic

Preexisting rock subjected *high temperatures* and *pressures*, often from deep burial or mountain building episodes form metamorphic rock over long periods of time.

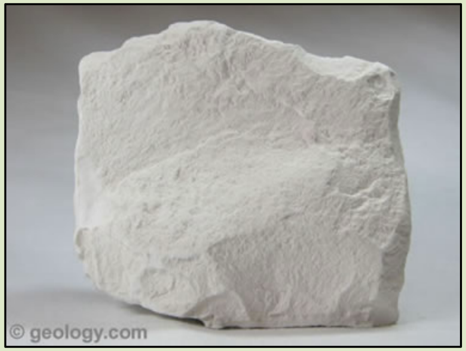
Ex. gneiss, schist

The Rock Cycle: Three Major Types of Rocks

Sedimentary

Sandstone

Limestone



Coal

Igneous

Basalt

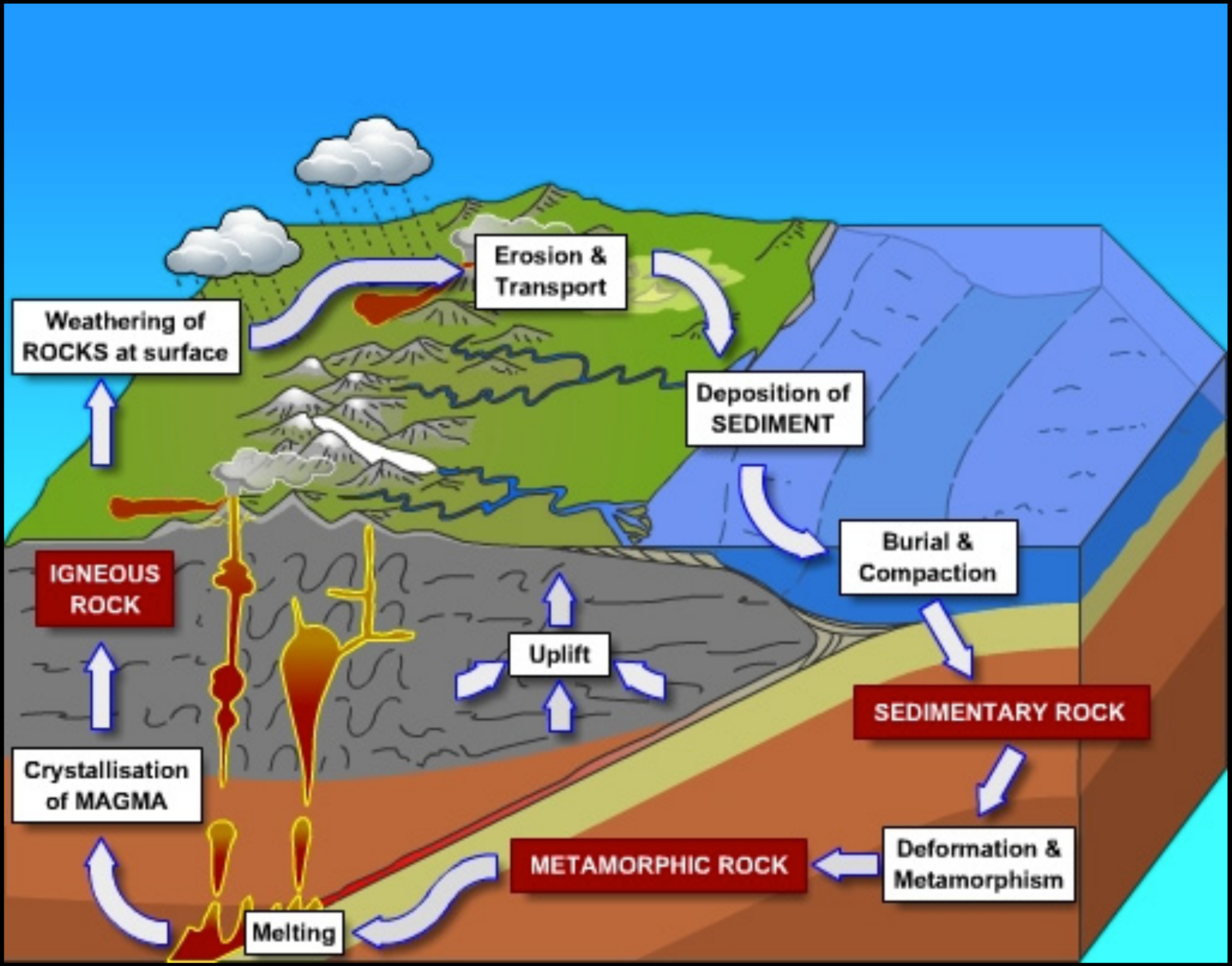
Granite

Metamorphic

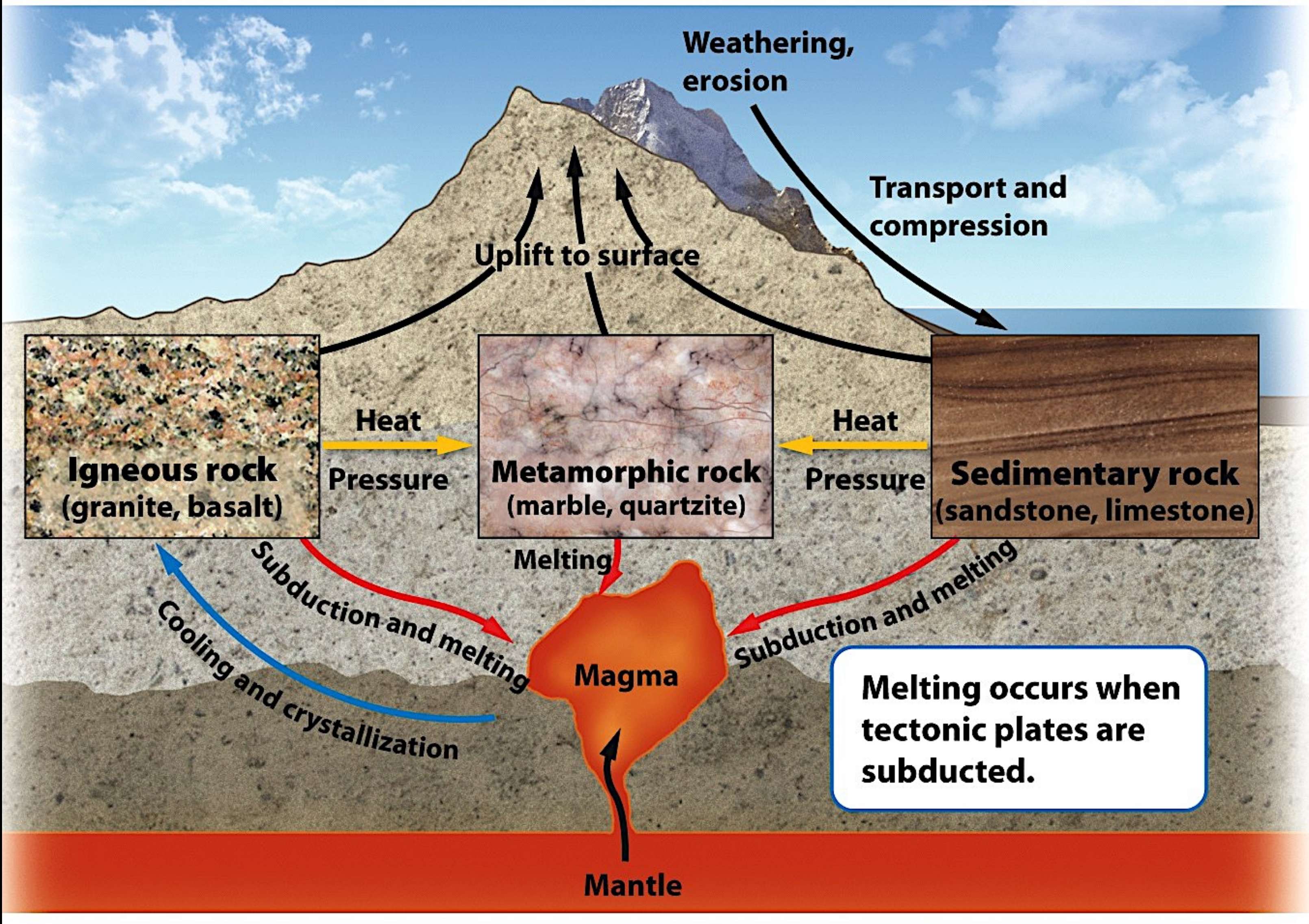
Schist

Gneiss

The Rock Cycle



The Rock Cycle



Geologic Processes

Weathering and Erosion

External Processes: Powered by energy from the sun and Earth's gravity; tend to wear down earth surface.

Erosion: Material is dissolved, loosened, worn away, then carried and deposited somewhere else. Work of streams: creates valleys, canyons, deltas.

Weathering: physical, chemical and biological break down of rocks and minerals into smaller particles that build soil.

Chemical Weathering: One or more chemical reactions slowly decompose rock. Most reactions involve rock reacting with O_2, CO_2, H_2O, moisture in atmosphere. Accelerated by rain and high temperatures.

Mechanical or Physical Weathering: large rock mass is broken into smaller fragments. Agents are wind and rain. More rapid in tropical areas with high temps.

Biological Weathering: work of burrowing animals and insects; movement of soil by earthworms

Geologic Processes