

Introduction to Geology

Geology literally means "study of the Earth."



Physical geology examines the materials and processes of the Earth.
Historical geology examines the origin and evolution of our planet through time.

Geology seeks to understand the origin of our planet and our place in the Universe – answers to these questions are also posed outside of the realm of science

The Earth System: From space, Earth looks small, finite and fragile.



The Earth is composed of several integrated parts (spheres) that interact with one another:

- **atmosphere**
- **hydrosphere**
- **solid earth (lithosphere)**
- **biosphere**

Hydrosphere: the global ocean is the most prominent feature of our (blue) planet. The oceans cover ~71% of our planet and represent 97% of all the water on our planet.

Atmosphere: the swirling clouds of the atmosphere represent the very thin blanket of air that covers our planet. It is not only the air we breathe, but protects us from harmful radiation from the sun.

Biosphere: includes all life on Earth - concentrated at the surface. Plants and animals don't only respond to their environment but also exercise a very strong control over the other parts of the planet.

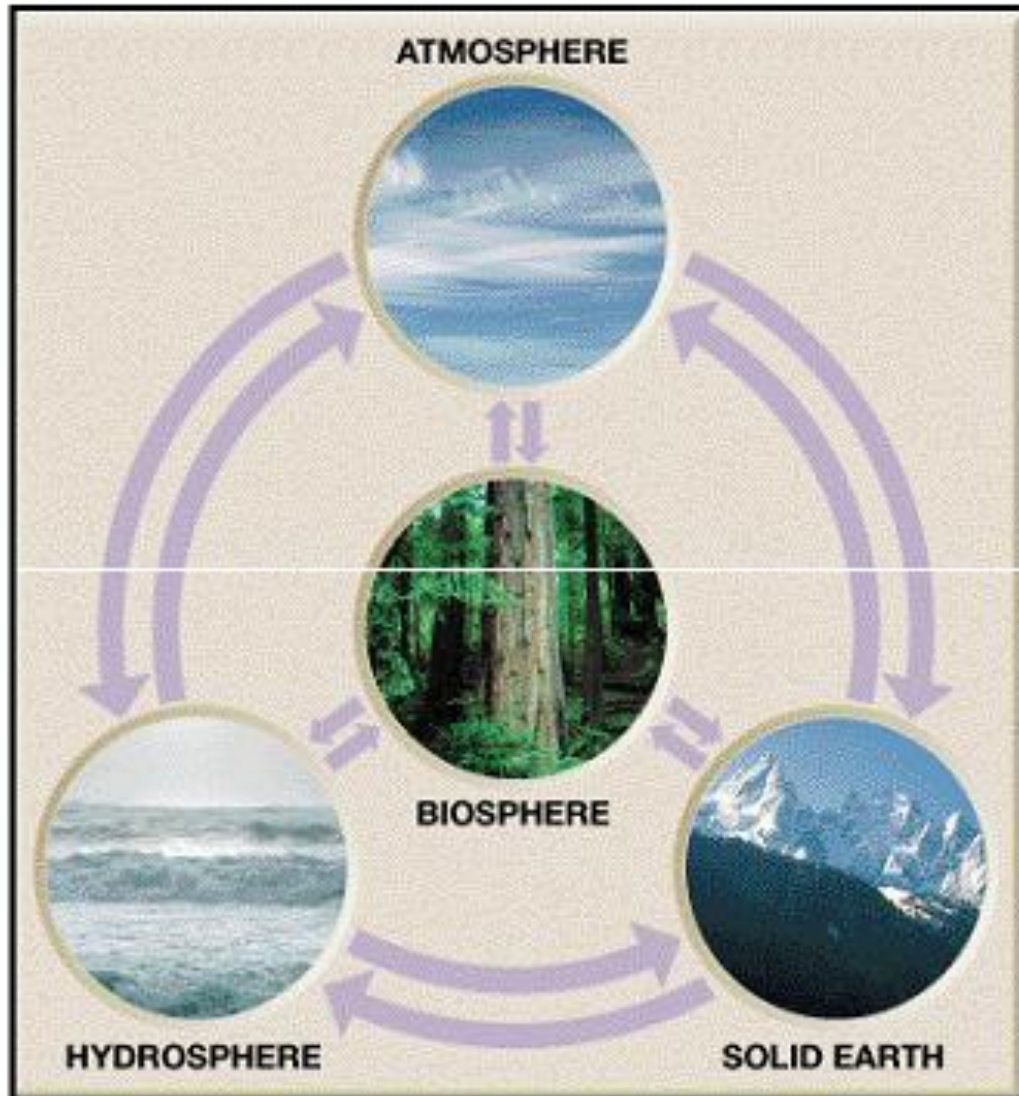
Solid Earth: represents the majority of the Earth system. Most of the Earth lies at inaccessible depths. However, the solid Earth exerts a strong influence on all other parts (ex. magnetic field).



This figure shows the dynamic interaction between the major spheres.

As humans, we desire to divide the natural world into artificial portions to make it easier. It should be stressed that these divisions are artificial.

What are some of the interactions between these spheres?



The Rock Cycle

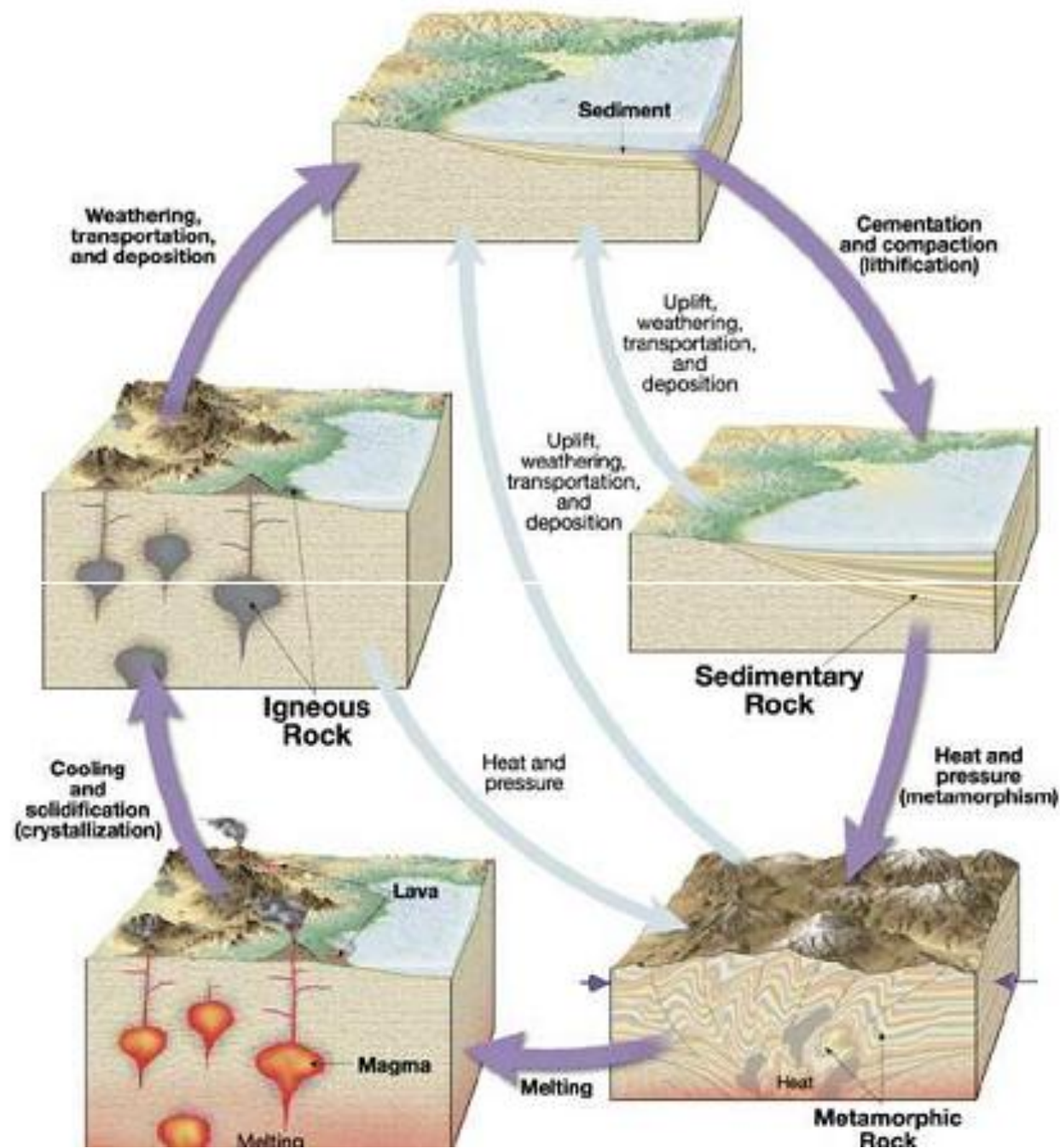
Three basic rock types:

igneous - form from magma/lava

sedimentary - form from sediment and chemical precipitation from seawater

metamorphic - form from other rocks that recrystallize under higher pressures and/or temperatures.

A number of geological processes can transform one rock type into another.



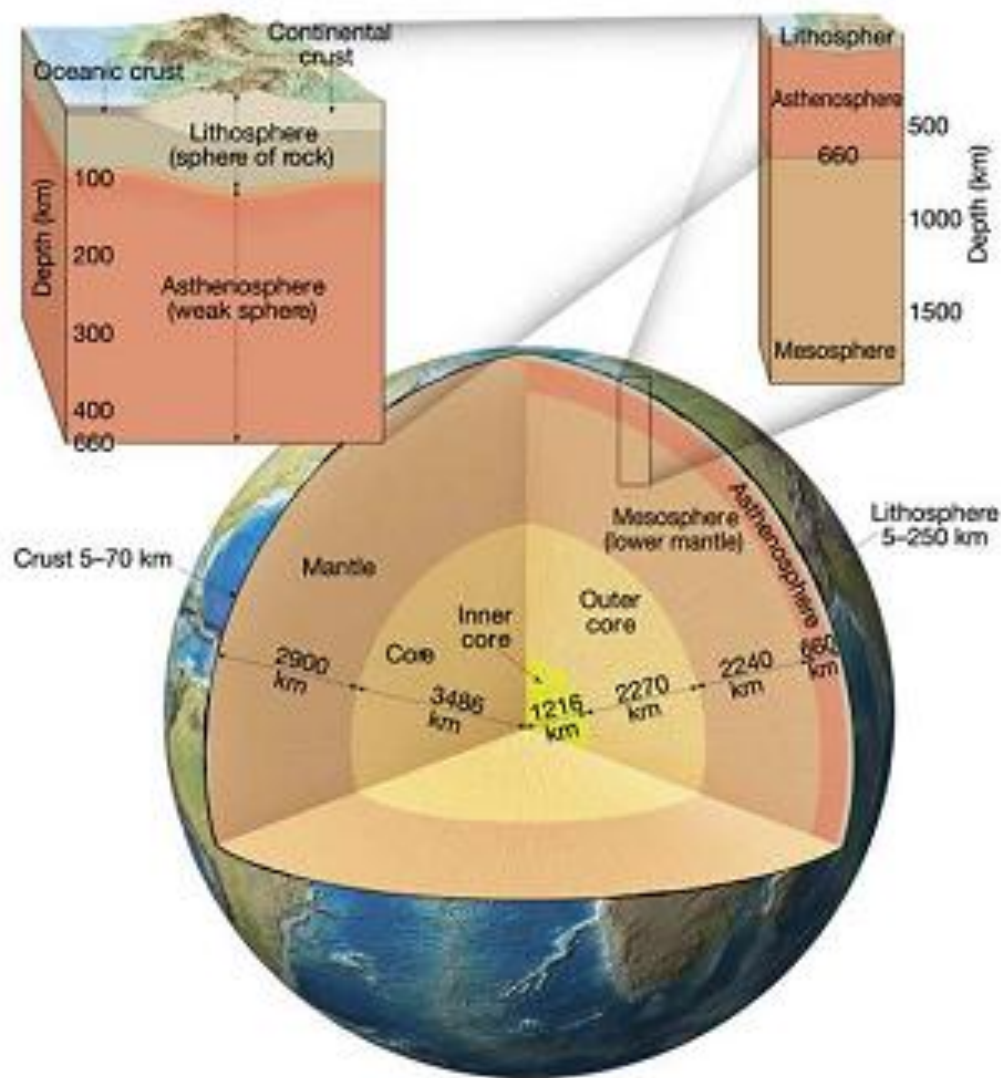
Earth's Internal Structure

The Earth's interior is characterized by a gradual increase in temperature, pressure and density with depth.

At only 100 km depth, the temp is $\sim 1300^{\circ}\text{C}$.

At the Earth's center, the temperature is $>6700^{\circ}\text{C}$.

The pressure in the crust increases ~ 280 bars for every kilometer depth.

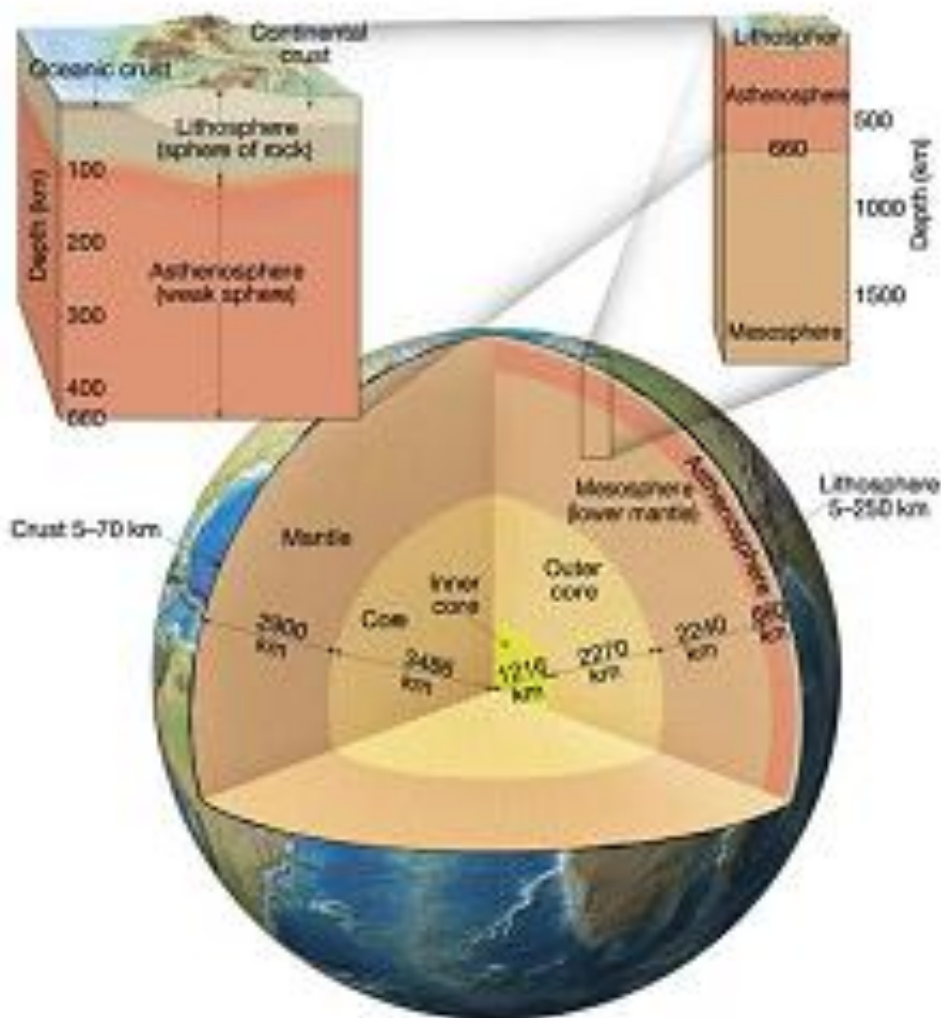


Earth's Internal Structure

The Earth consists of **3** major regions marked by differences in chemical composition.

Crust: rigid outermost layer of the Earth.
Consists of two types:

1. **oceanic** - 3-15 km thick and is composed of *basalt* (igneous). Young (<180 million years old).
2. **continental** - up to 70 km thick and composed of a wide variety of rock types (ave. *granodiorite*). Ranges from young to old (>3.8 billion years old).



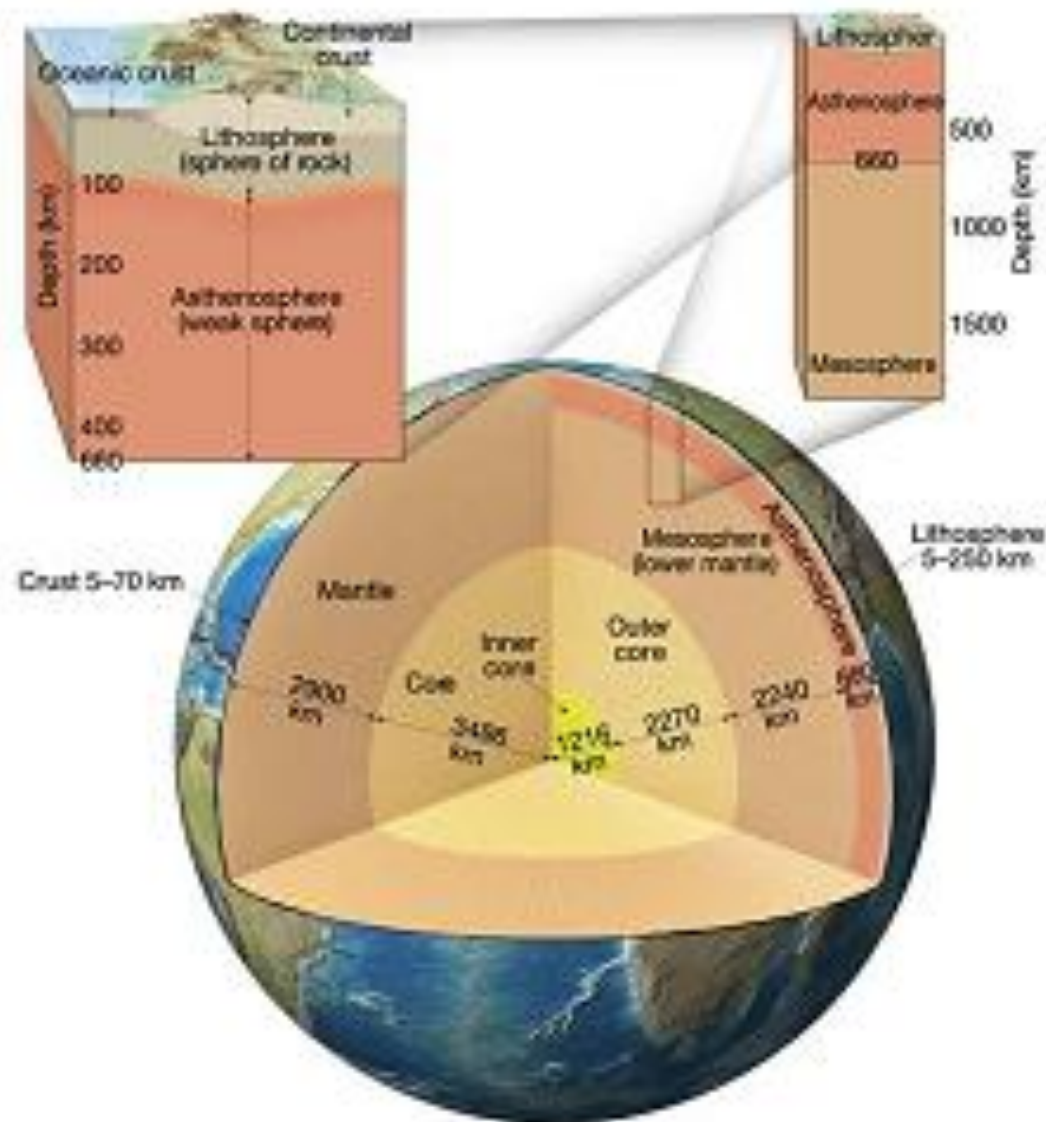
Earth's Internal Structure

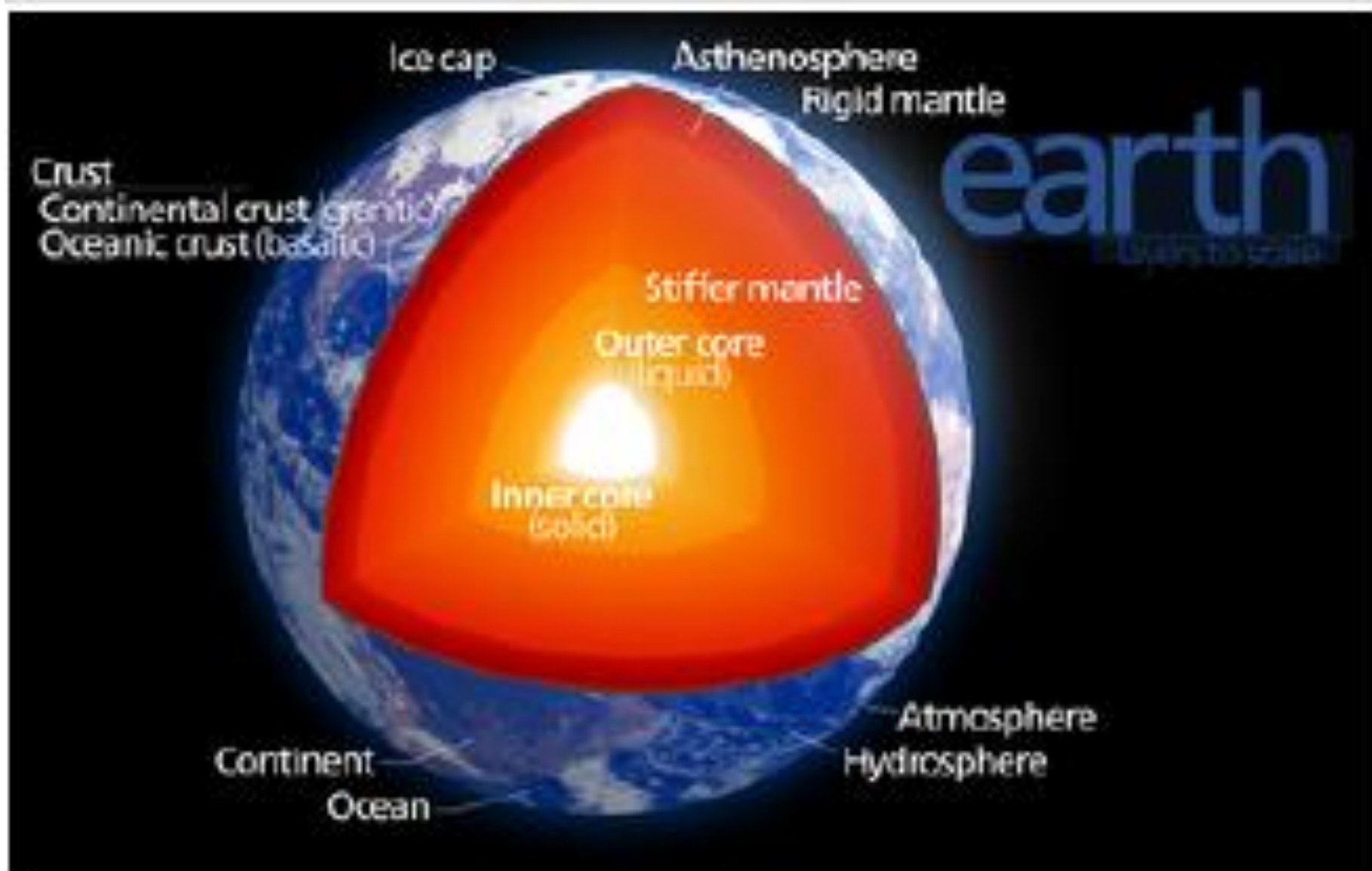
Mantle: comprises ~82% of the Earth by volume and is ~2900 km thick.

- The mantle is characterized by a change in composition from the crust.
- The mantle is able to flow (plastically) at very slow rates.

Core: composed of iron, nickel and other minor elements.

- The outer core is liquid — capable of flow and source of the Earth's magnetic field.
- The inner core is solid Fe-Ni. There is no major chemical difference between the outer and inner core.





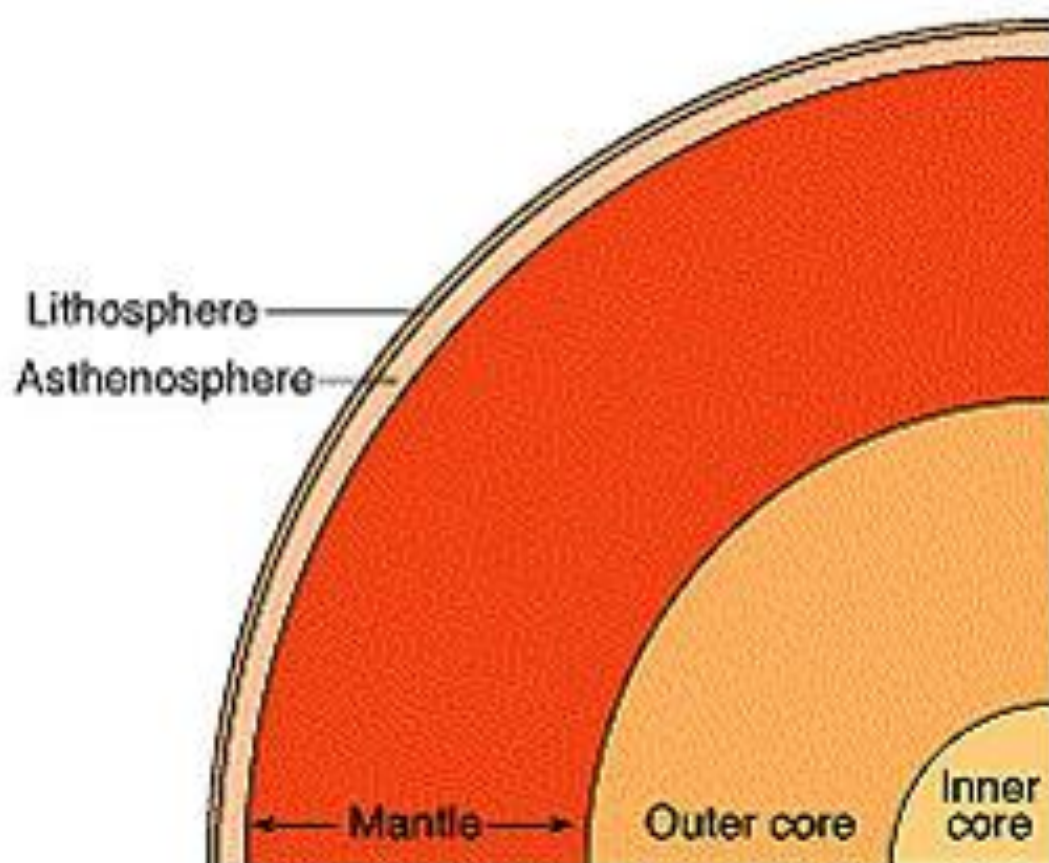
Lithosphere (0 to ~100 km)

The outer 75 km (with big variations between 10 and 300km) of the earth is a region which does not get heated up to near-melting because it is losing heat rapidly to the surface. This relatively cool shell is called the *lithosphere*. The lithosphere

is fractured into a few large plates

- just enough so that the movement of the plates can deliver interior heat to the surface particularly near the spreading boundaries, where two plates are moving apart, and new material wells up from depth.

- 1.Continental
- 2.Oceanic



Asthenosphere (~100 to 660 km)

- Radioactive decay causes the Earth to heat up on time scales of millions of years. In the course of tens/hundreds of millions of years, this heat production is enough to warm the interior by hundreds of °C.
- This heat is carried away by the convective circulation of the earth's interior. The convection delivers heat to the surface, so it can eventually be lost into space (The average geothermal heat flux through the earth surface is 70 mW/m^2)
- Most of the earth's interior is heated to a temperature $> 300^\circ\text{C}$ which makes it ductile, so that it is soft, and can flow like a viscous liquid. You have seen this behavior as glass is heated to near its melting point. The soft region (just below the lithospheric plates) is called the asthenosphere

Mesosphere / Lower Mantle (660 to 2900 km)

- Rock in the lower mantle gradually strengthens with depth, but it is still capable of flow.

Outer (2900 to 5170 km) and Inner Core (5170 to 6386 km)

- Outer core is liquid and composed of an iron-nickel alloy. Convective flow of this fluid generates much of the Earth's magnetic field.
- Inner core is solid iron-nickel alloy. It is hotter than the outer core, but the intense pressure keeps it solid.

Plate Tectonics

A relatively recent theory that the Earth's crust is composed *of rigid plates that move relative to one another.*

Plate movements are on the order of a few centimeters /year -about the same rate as about the same rate as fingernails grow!

Major & Minor Plates

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Pacific Basin & Plate Boundaries

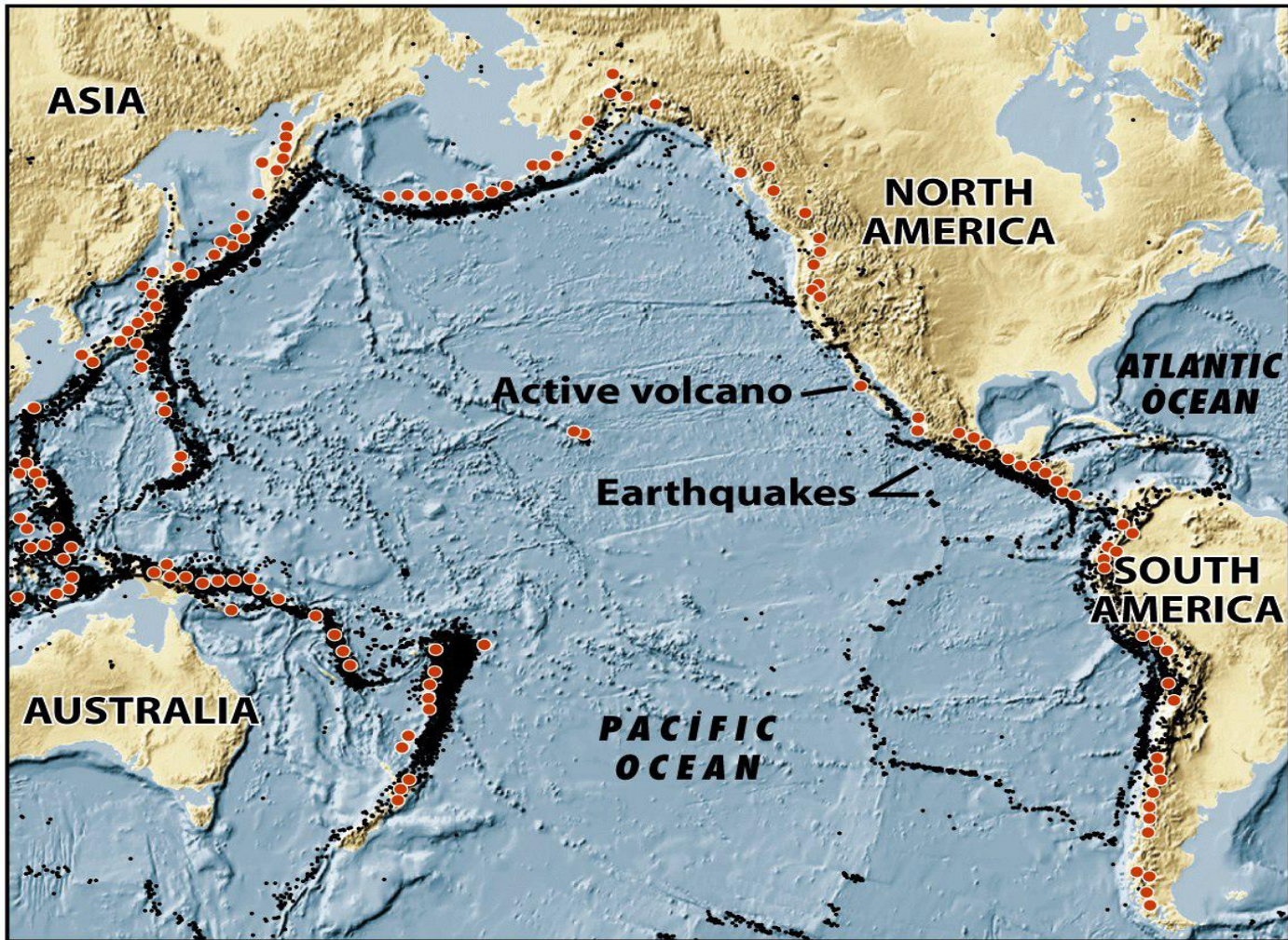


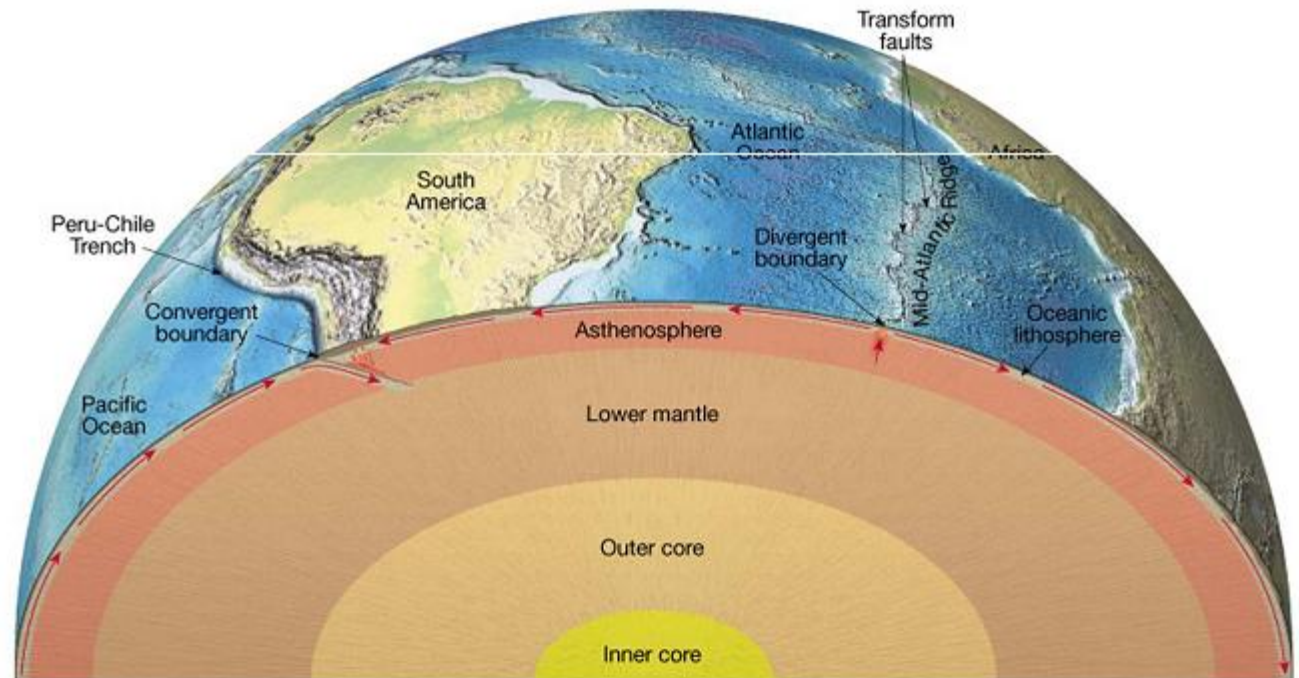
Figure 2-4
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1. Pacific plate boundary is often termed the **"Ring of Fire"**.
2. Pacific is the only large plate that lacks a continent.
3. Although the east-Pacific ocean ridge has the fastest spreading rate, overall the Pacific plate is decreasing in area as the Atlantic ocean basin grows.

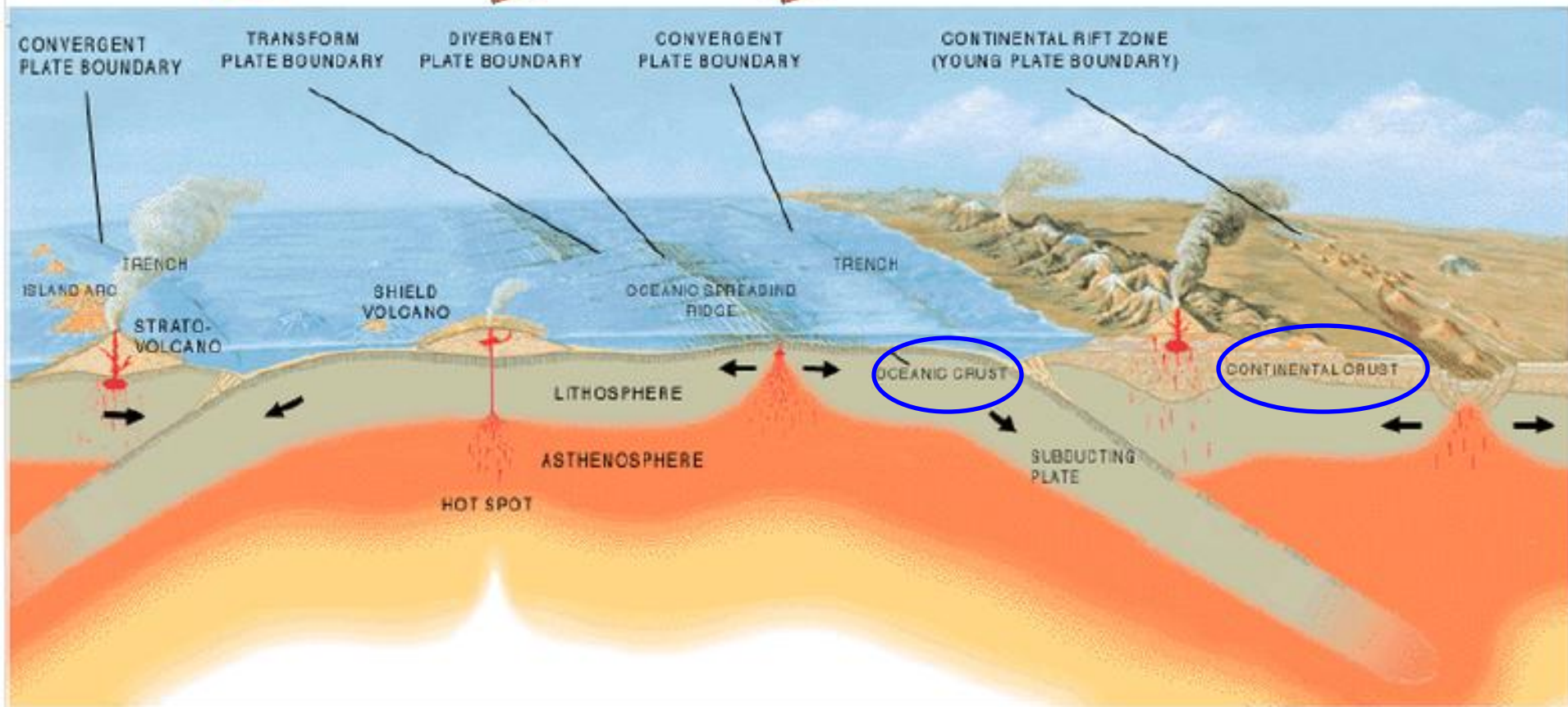
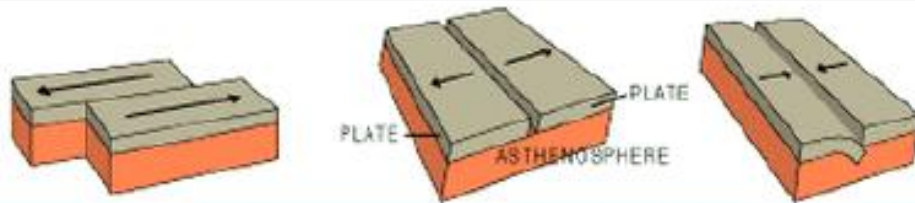
There are 3 types of plate Boundaries:

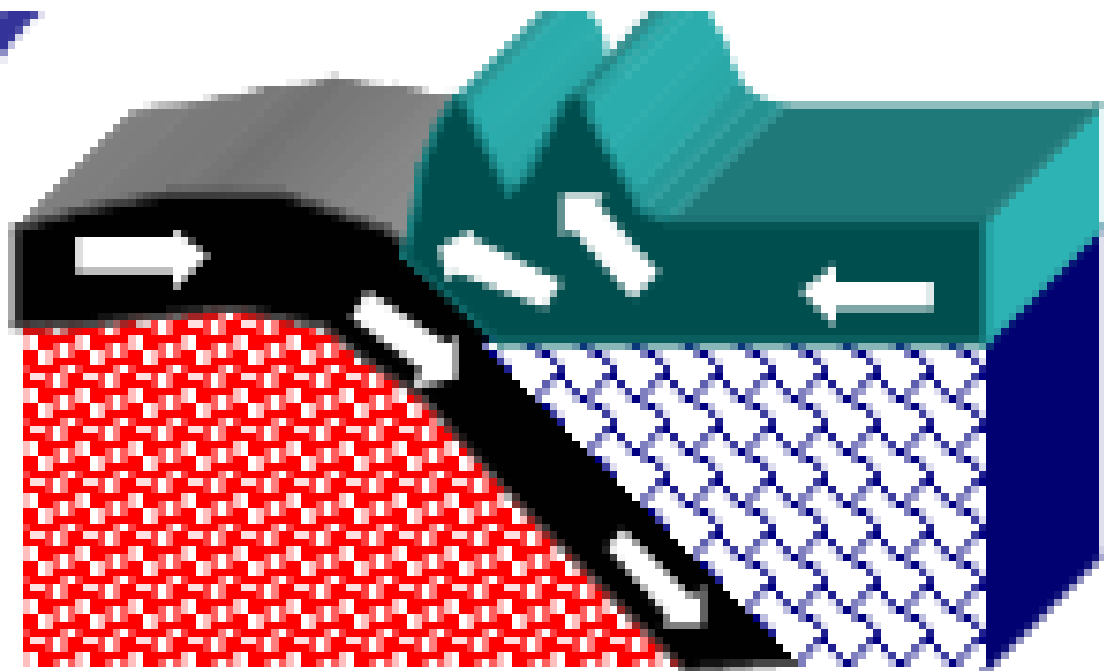
1. Divergent 2. convergent 3. transform

- **Convergent boundaries** - plates move together forming a subduction zone and mountain chains.
- **Divergent boundaries** - plates move apart forming the mid-ocean ridge and seafloor spreading.
- **Transform boundaries** - plates grind past one another. These boundaries subdivide the mid-ocean ridge and also form the San Andreas fault system

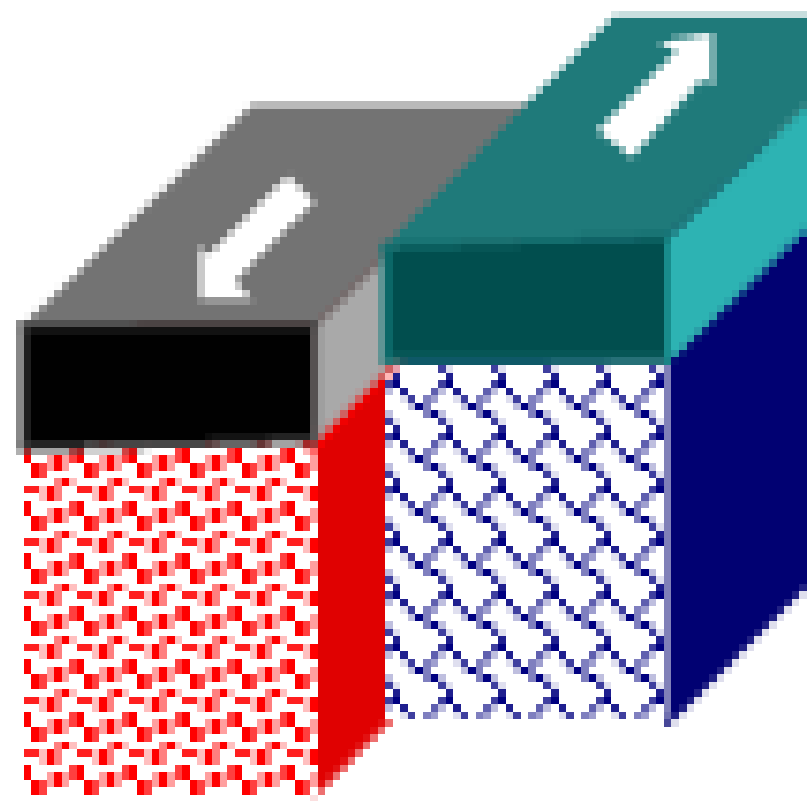


Tectonic Plate Boundaries

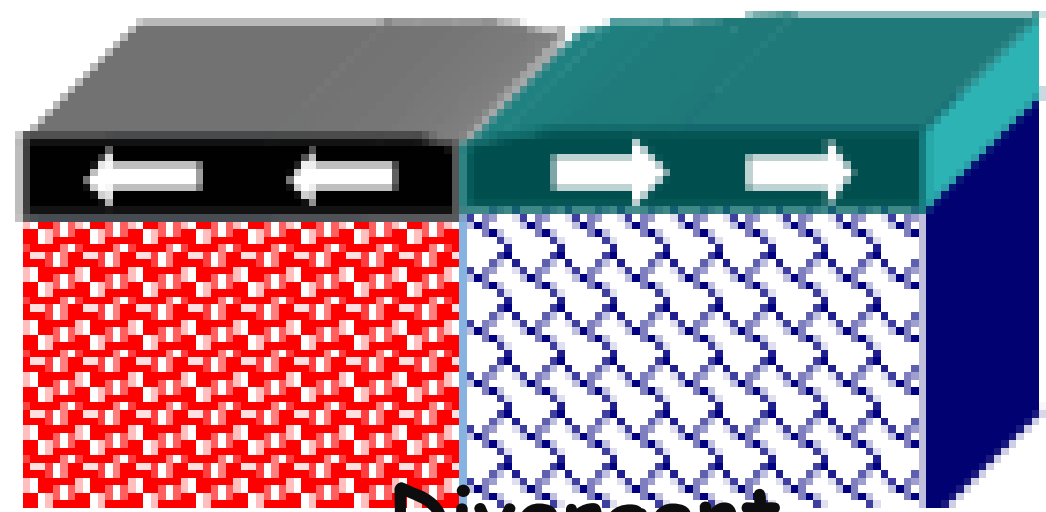




Convergent Boundary



Transform Boundary

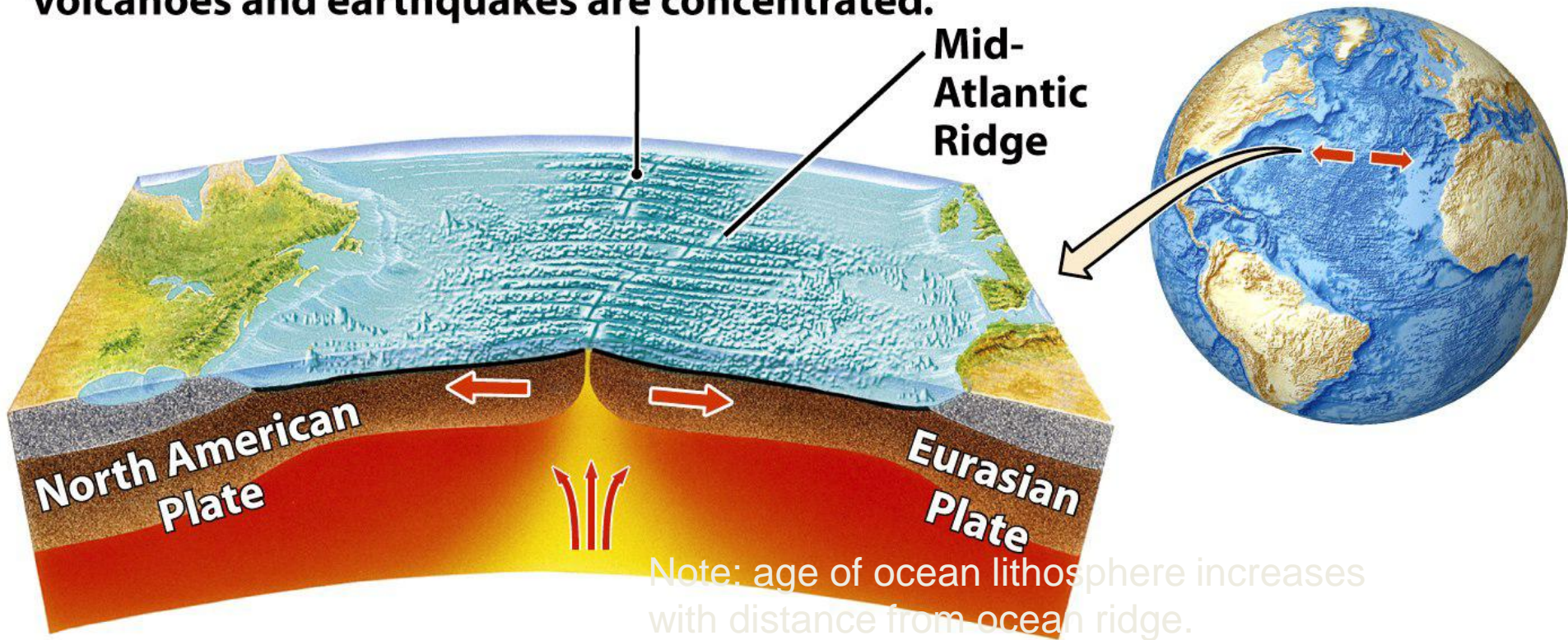


Divergent

Divergent Boundary Cross-Section

DIVERGENT BOUNDARIES Oceanic Plate Separation

Rifting and spreading along a narrow zone have created the **Mid-Atlantic Ridge**, a mid-ocean mountain chain where volcanoes and earthquakes are concentrated.



Divergent Continental Rift

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Convergent: Oceanic-to-Oceanic

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Andean-type: Oceanic-to-Continental

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Transforms: Oceanic

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Transforms: Continental

TRANSFORM-FAULT BOUNDARIES

Continental Transform Fault

The San Andreas fault in California, where the Pacific Plate slides past the North American Plate, is an example of a transform fault that offsets continental crust.

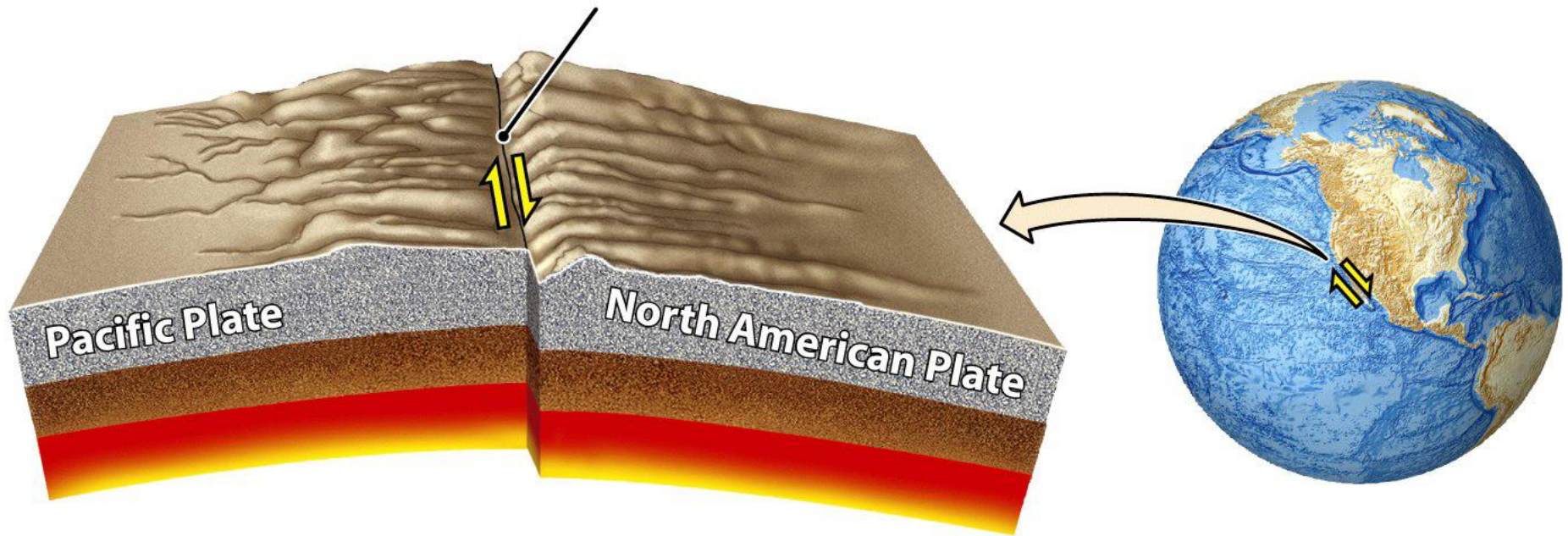


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