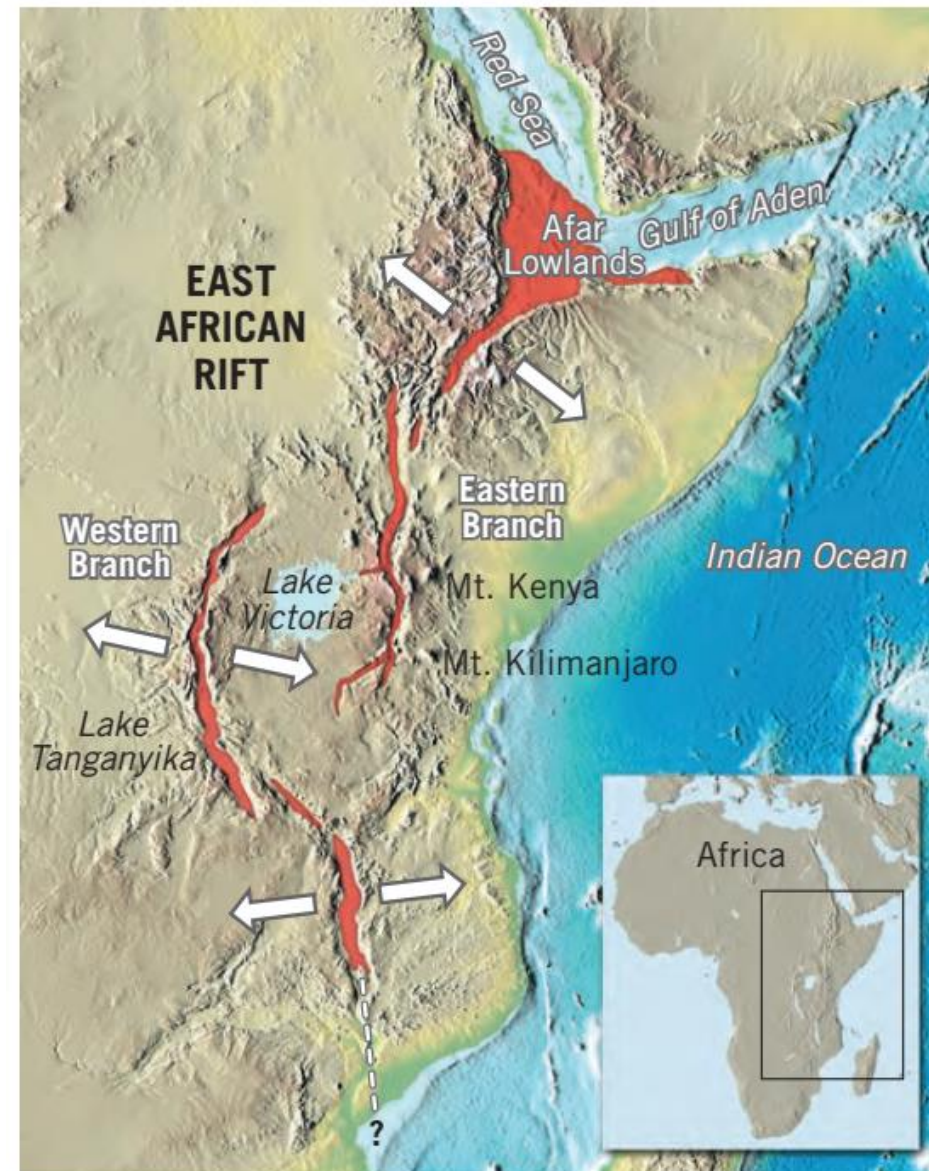
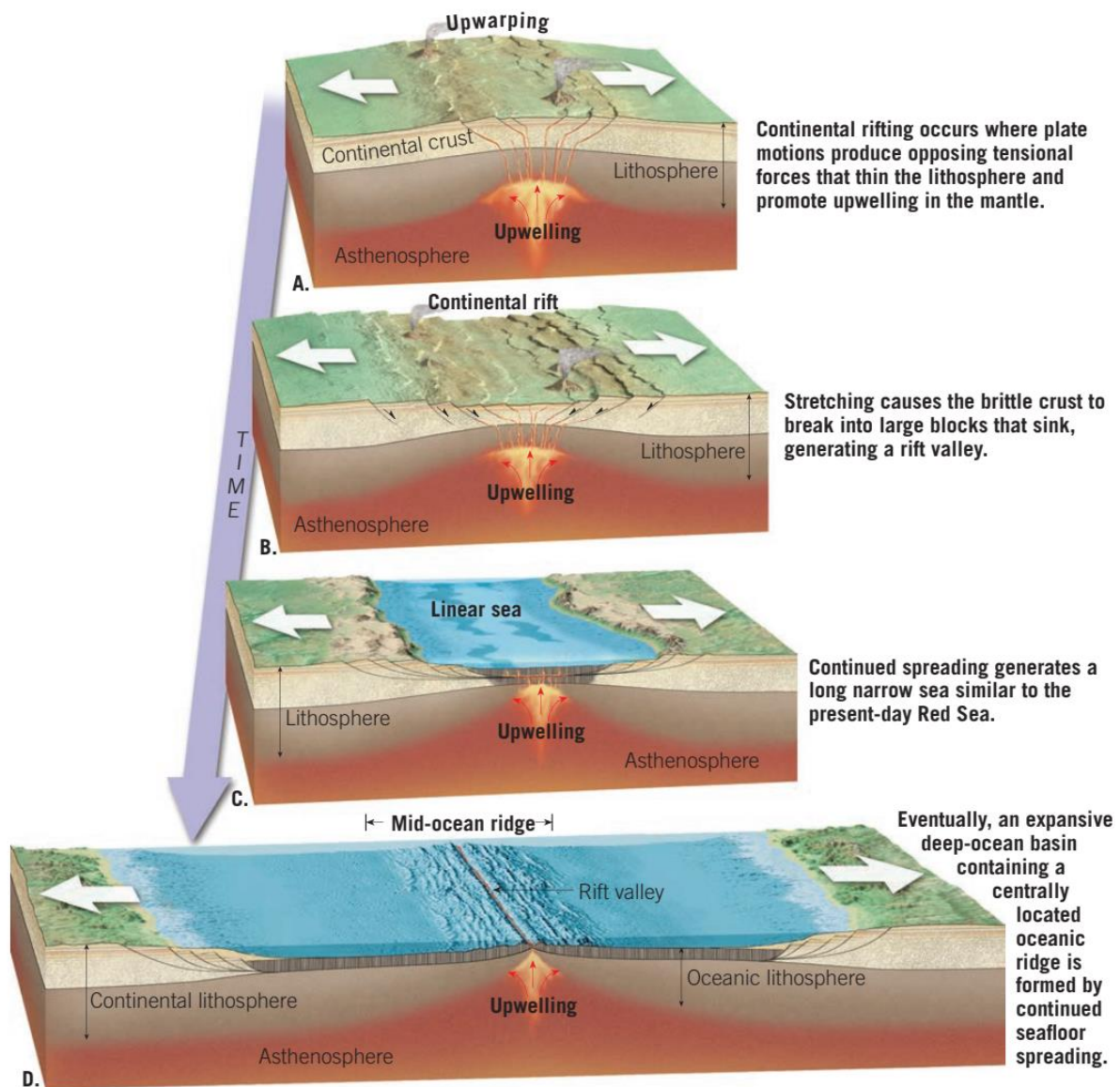


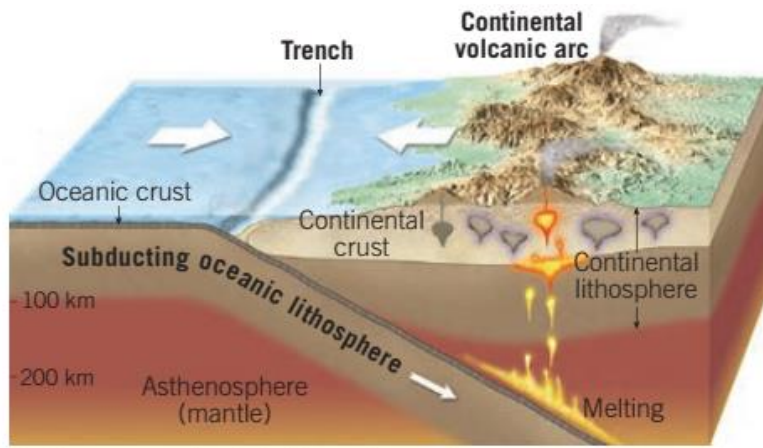
# Earth and Planetary Sciences (ES1101)

(Continental Drift, Sea floor Spreading, and Plate Tectonics)  
(Autumn 2021 by Gaurav Shukla)

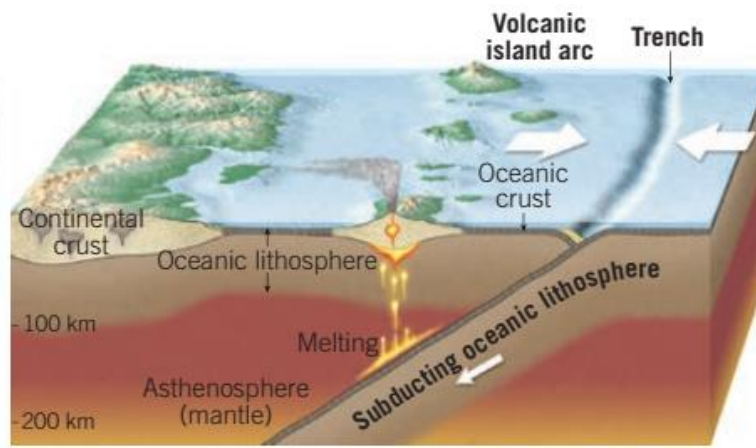
**Book:** 1) Understanding Earth by Grotzinger & Jordan (Textbook)  
2) Earth: An introduction to Physical Geology by Tarbuck & Lutgens  
3) The Solid Earth: An introduction to global geophysics by Fowler



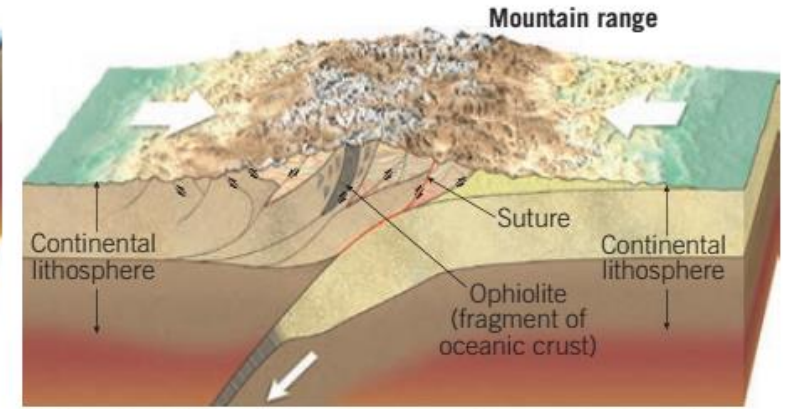




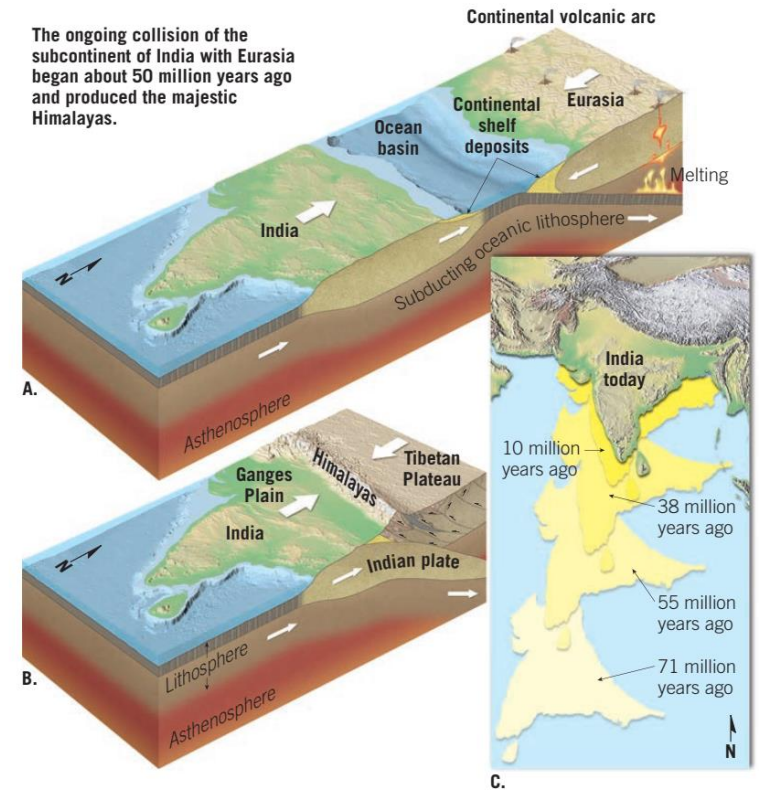
**A. Convergent plate boundary where oceanic lithosphere is subducting beneath continental lithosphere.**

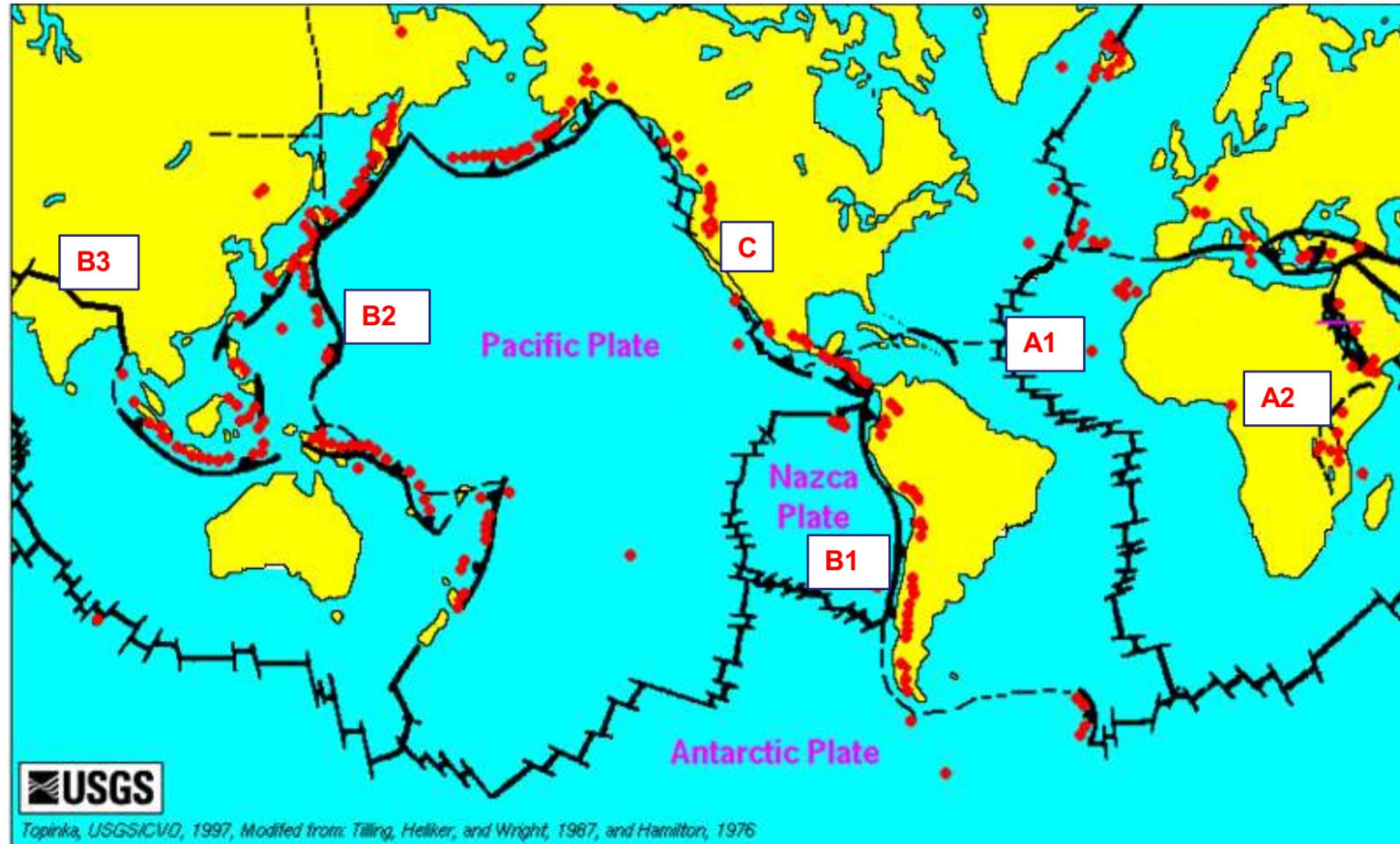


**B. Convergent plate boundary involving two slabs of oceanic lithosphere.**



**C. Continental collisions occur along convergent plate boundaries when both plates are capped with continental crust.**





A1: Mid Oceanic Ridge

A2: Continental Rift

B1: Oceanic- Continental Convergence

B2: Oceanic-Oceanic Convergence

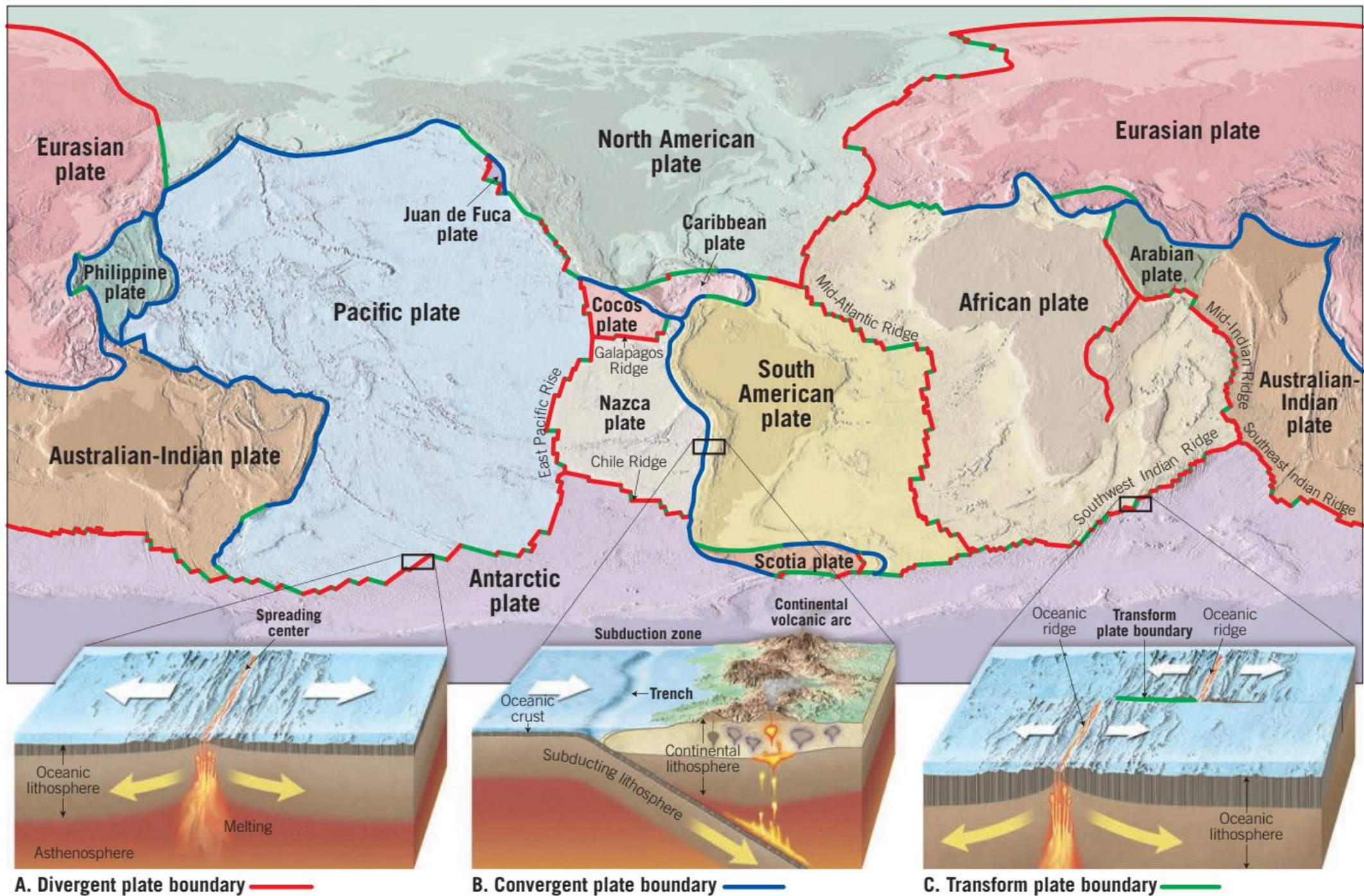
B3: Continental- Continental Convergence

C: Transform Boundary

} Divergent Boundary

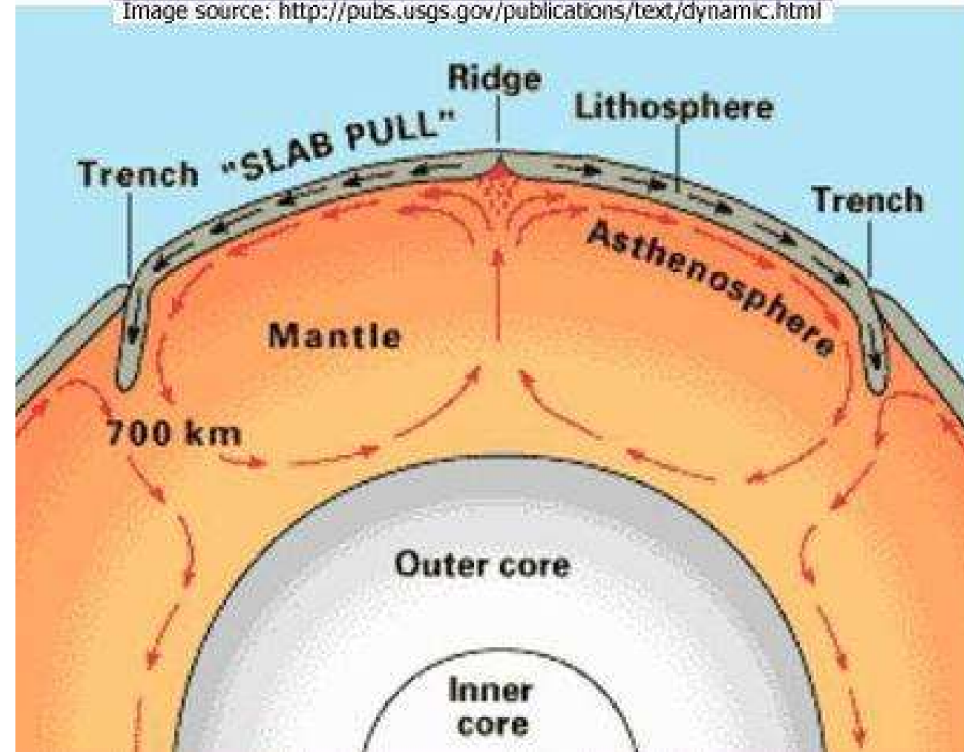
} Convergent Boundary





## The Forces That Cause Plate Tectonics

Image source: <http://pubs.usgs.gov/publications/text/dynamic.html>

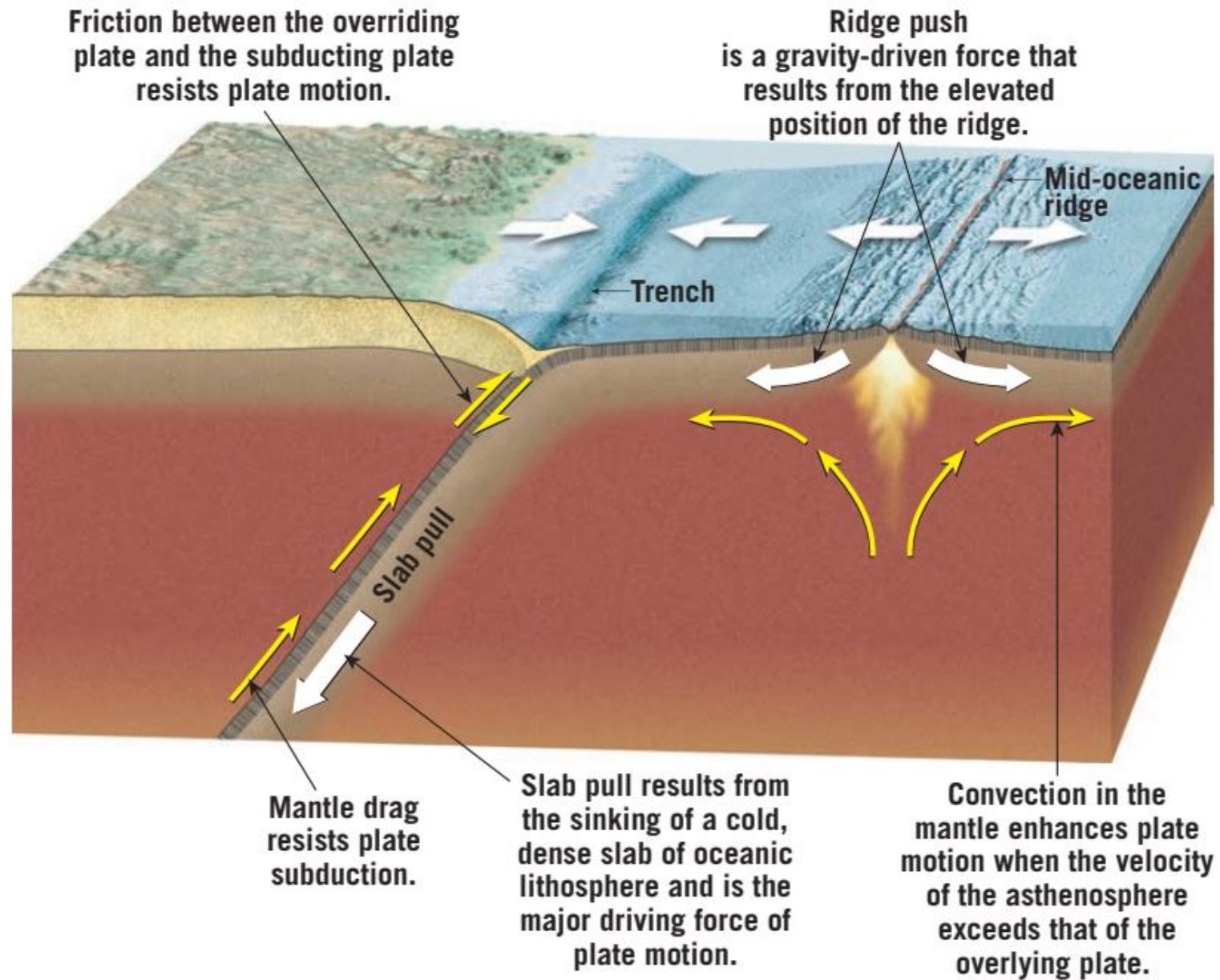


The lithosphere is the crust and the upper mantle. The lithosphere is divided into plates. The plates move because of convection currents (shown above).

Convection is the major mechanism of energy transfer in the oceans, atmosphere, and Earth's interior.

**Convection currents** are when hot, less dense material rises, cools, becomes more dense and sinks.





**Figure 2.37** Forces that act on lithospheric plates

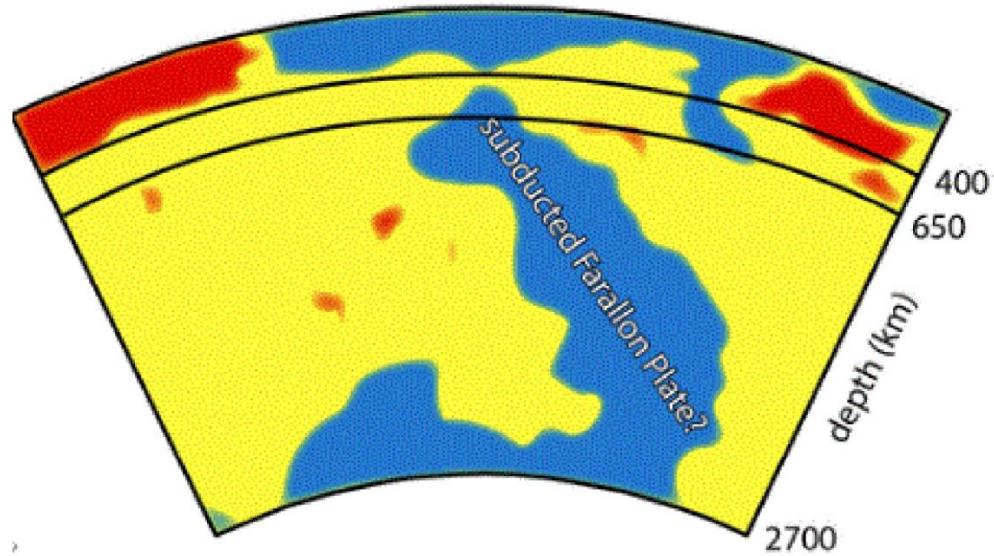
## **How far the Plates descend?**

- **For oceanic plate- oceanic plate subduction:**  
**Earthquakes are common upto 300 km depth,**  
**but usually does not occur at depths below 660Km**
- **Seismic imaging allows tracking of subducting plates: Remember that the relatively cold and hence dense subducting plate stands out in imaging**
- **When the plate reaches 660 Km depth, it becomes plastic and flows- unable to descend further**
- **Commonly held view is thus the maximum depth of subduction to be 660 Km**

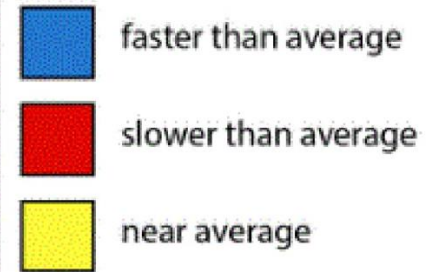
**However,.....**



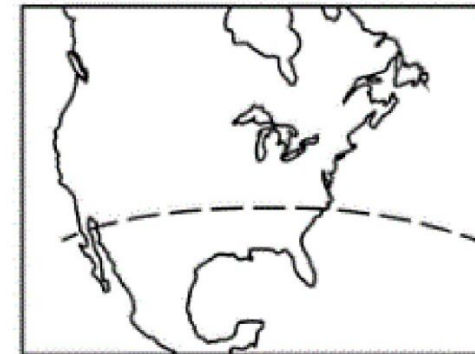
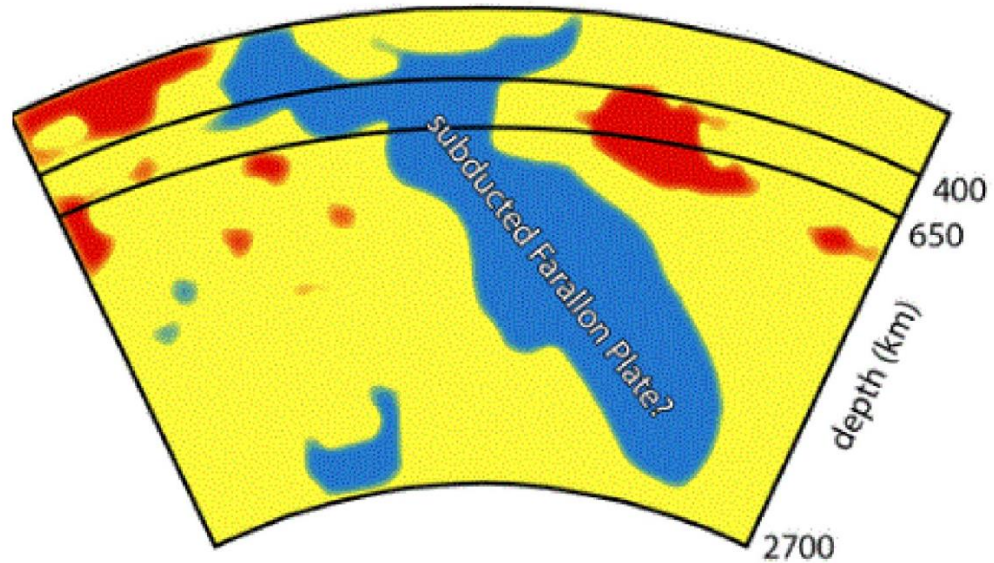
P-wave velocity variations



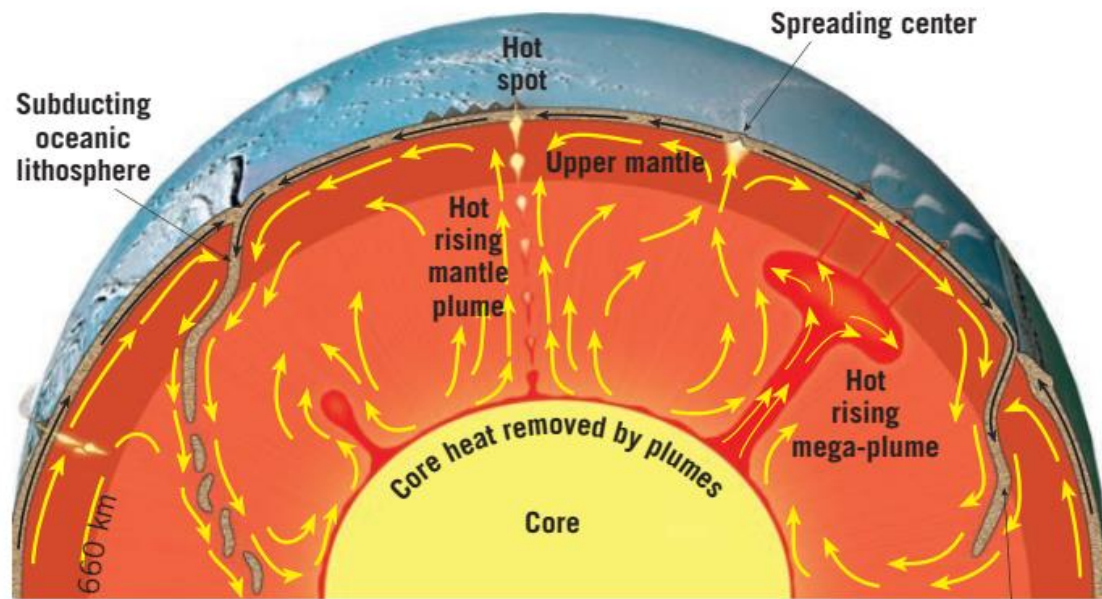
Seismic Velocity



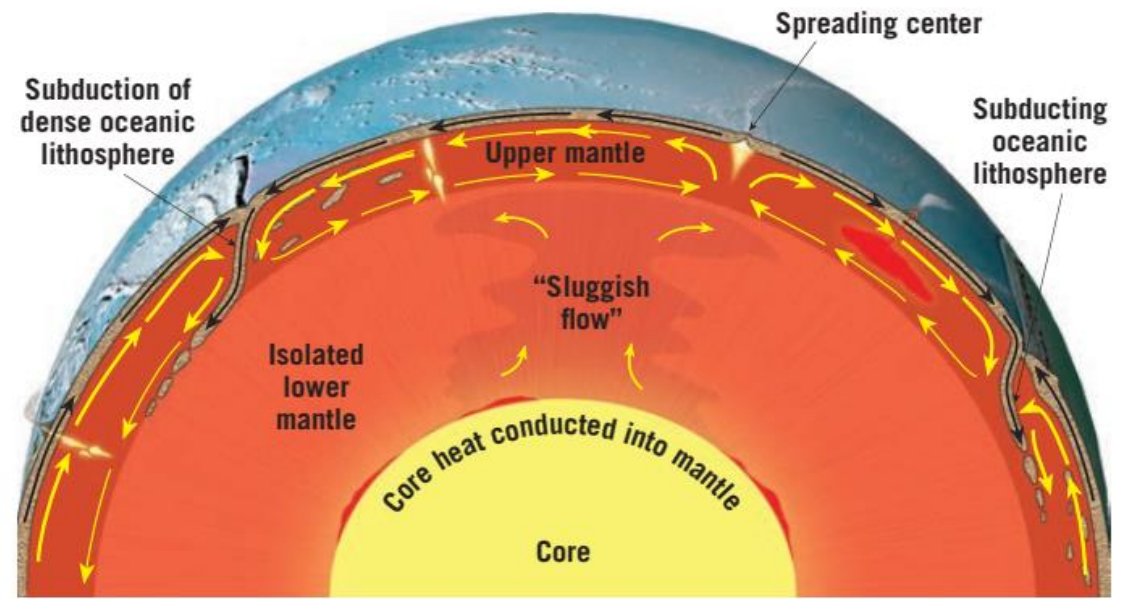
S-wave velocity variations



Approximate section location



**A.** In the “whole-mantle model,” sinking slabs of cold oceanic lithosphere are the downward limbs of convection cells, while rising mantle plumes carry hot material from the core–mantle boundary toward the surface.



**B.** The “layer cake model” has two largely disconnected convective layers. A dynamic upper layer driven by descending slabs of cold oceanic lithosphere and a sluggish lower layer that carries heat upward without appreciably mixing with the layer above.

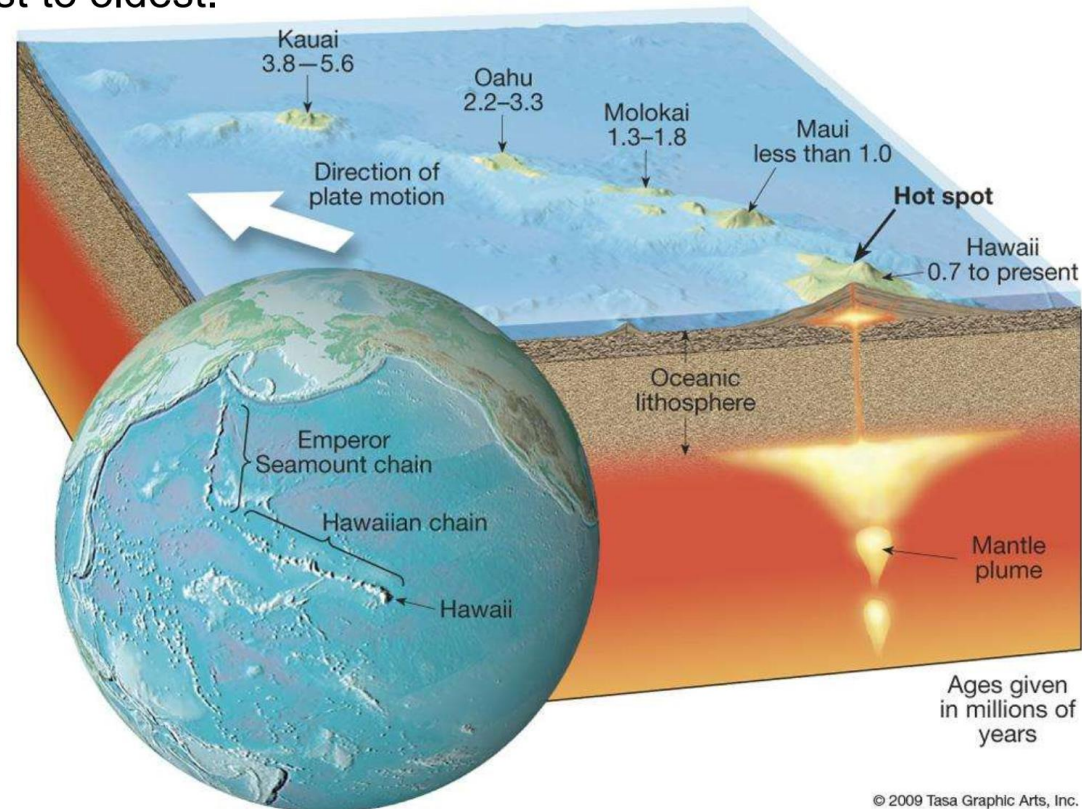


## Measuring plate movement

- Pacific plate is moving over a fixed magma plume generating a chain of volcanoes.
- Hawaii is currently on the top of the plume, so youngest island.
- The oldest island Kauai.
- Plate motion is from youngest to oldest.

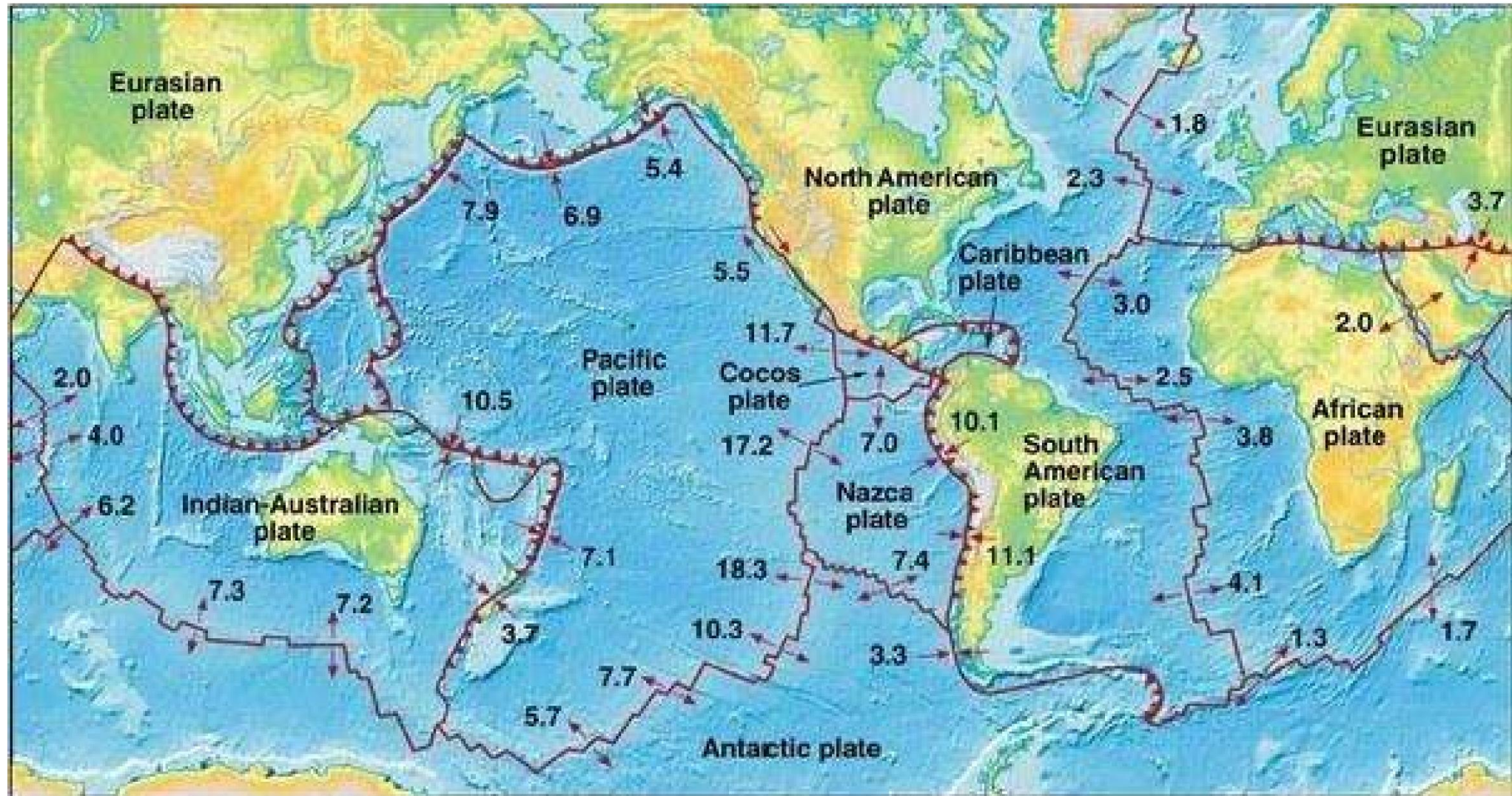
Which way is the Pacific plate moving?

GPS measurements show continuous movement of the plates.





# Plate velocity



Ridge axis      Subduction zone      Direction of movement