Module 11

Plate Tectonics

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PLATE TECTONICS

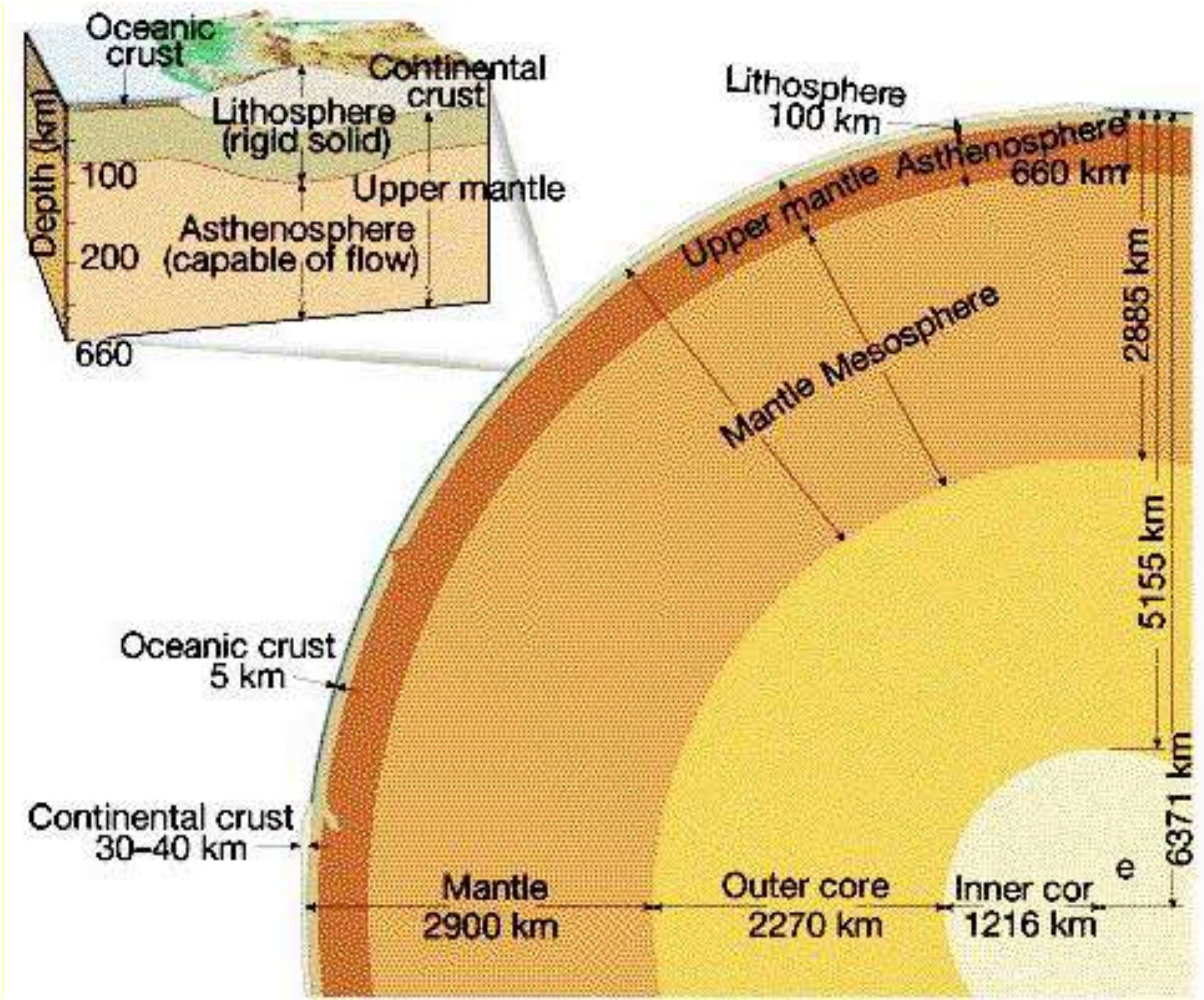
Continental drift

- “continents have moved in relation to one another”

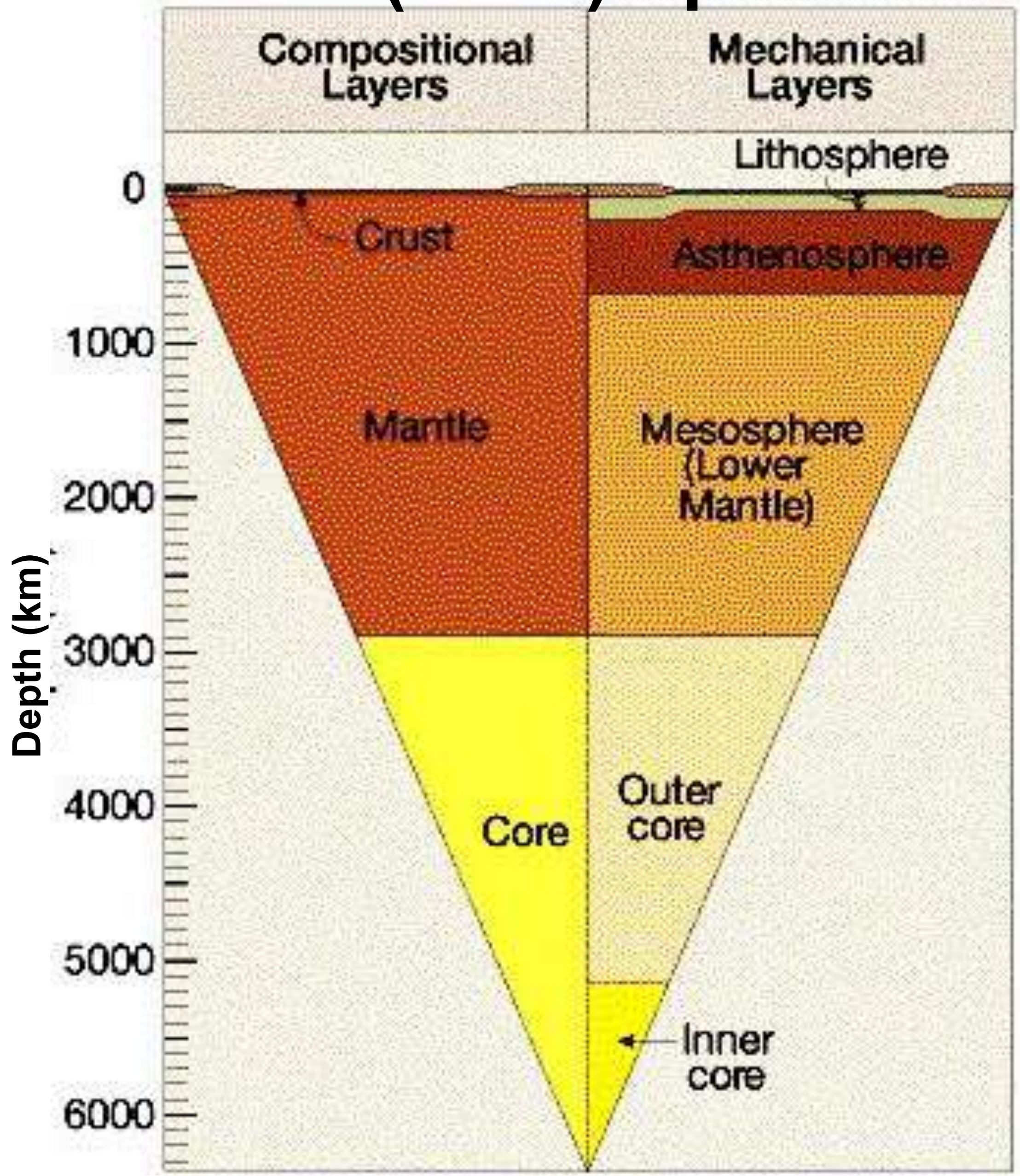
Plate tectonics

- “lithosphere is believed to be broken into individual plates that move in response to convection in the (upper) mantle”
- The margins of the plates are sites of considerable geologic activity.

Crust Mantle Core (CMC)-sphere



Crust Mantle Core (CMC)-sphere



rocks

ultrabasic igneous rocks (MgO, SiO_2)

Fe, Ni

cold, rigid, brittle

hot, plastic

Δ = 3,3– 4,3 g/cm^3

hot, high pressure, rigid, brittle

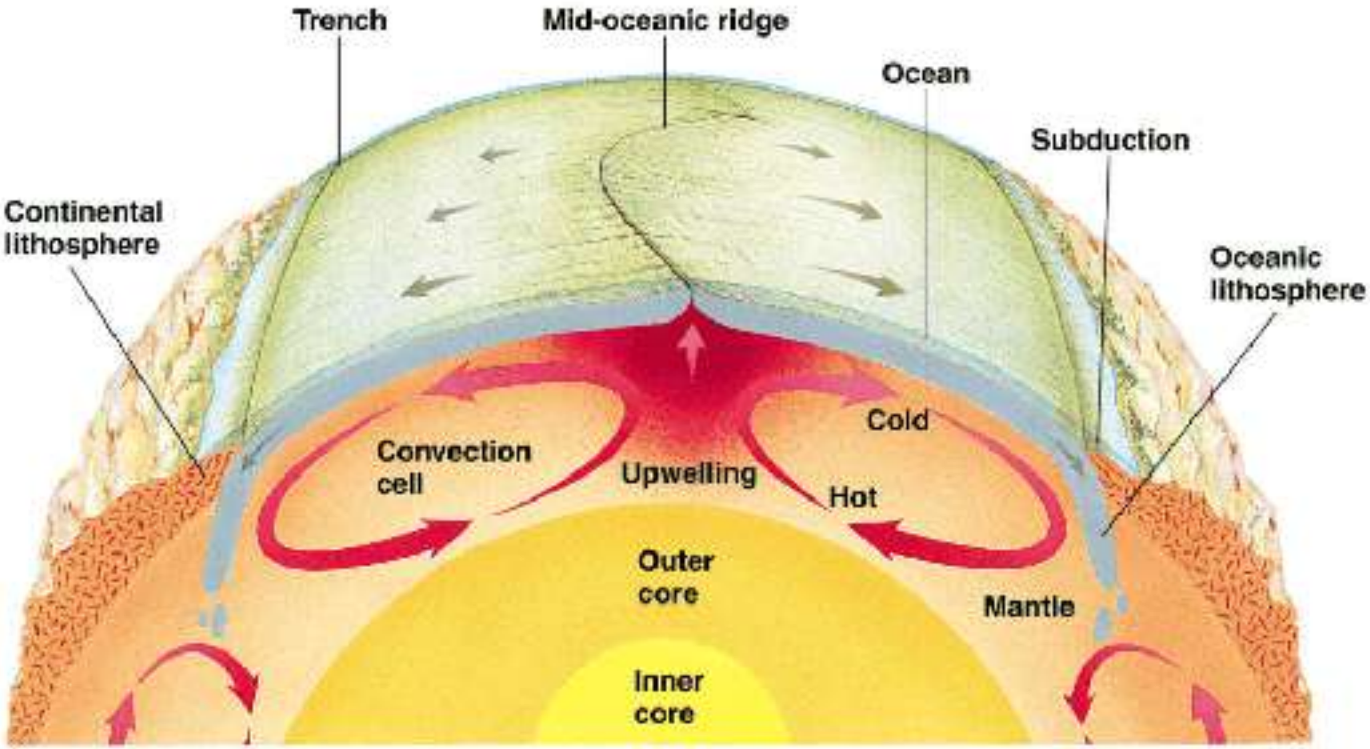
Liquid

4500^0 C

solid

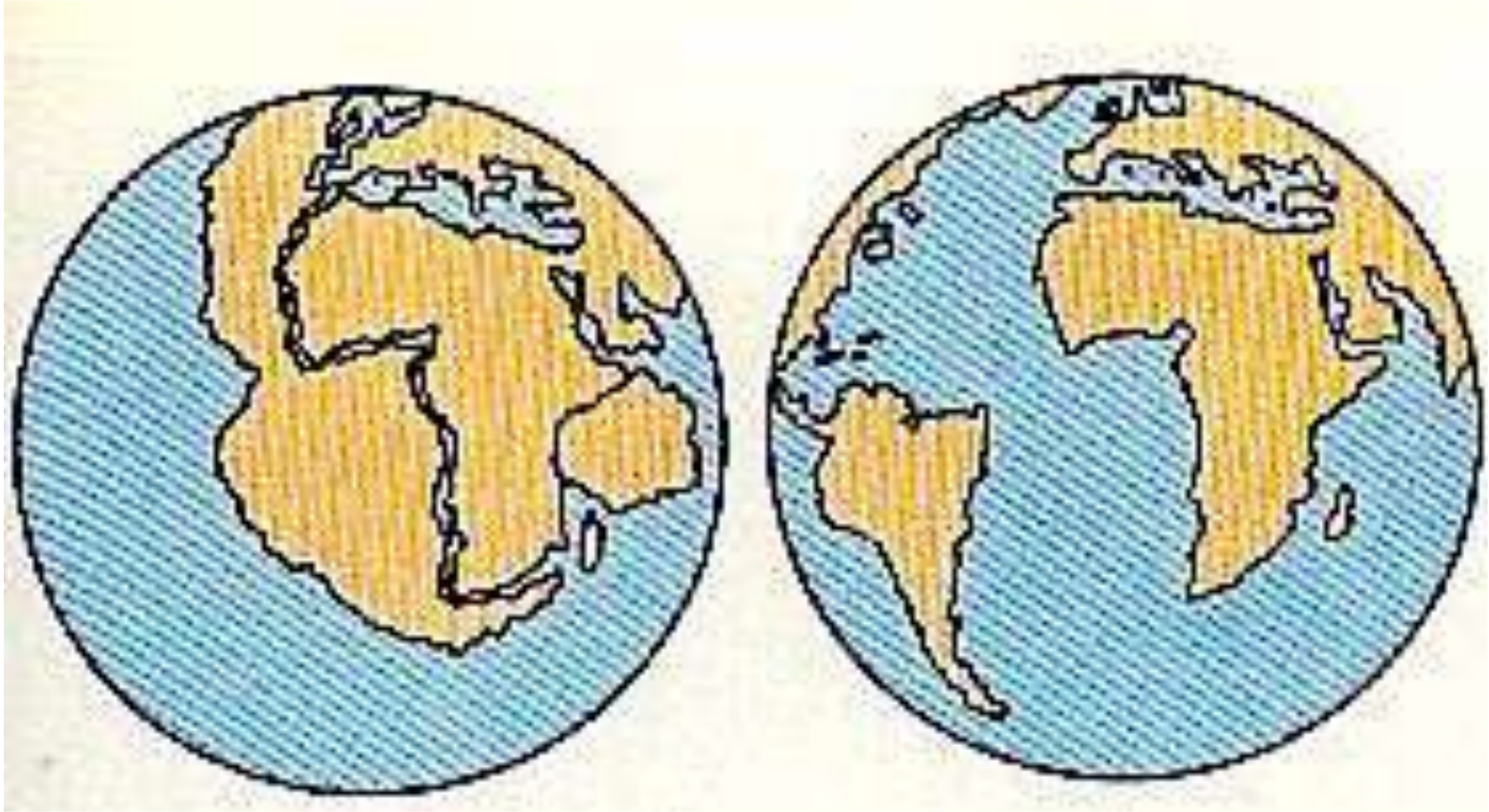
Plate Tectonic Theory

- Lithosphere is broken into individual pieces called plates



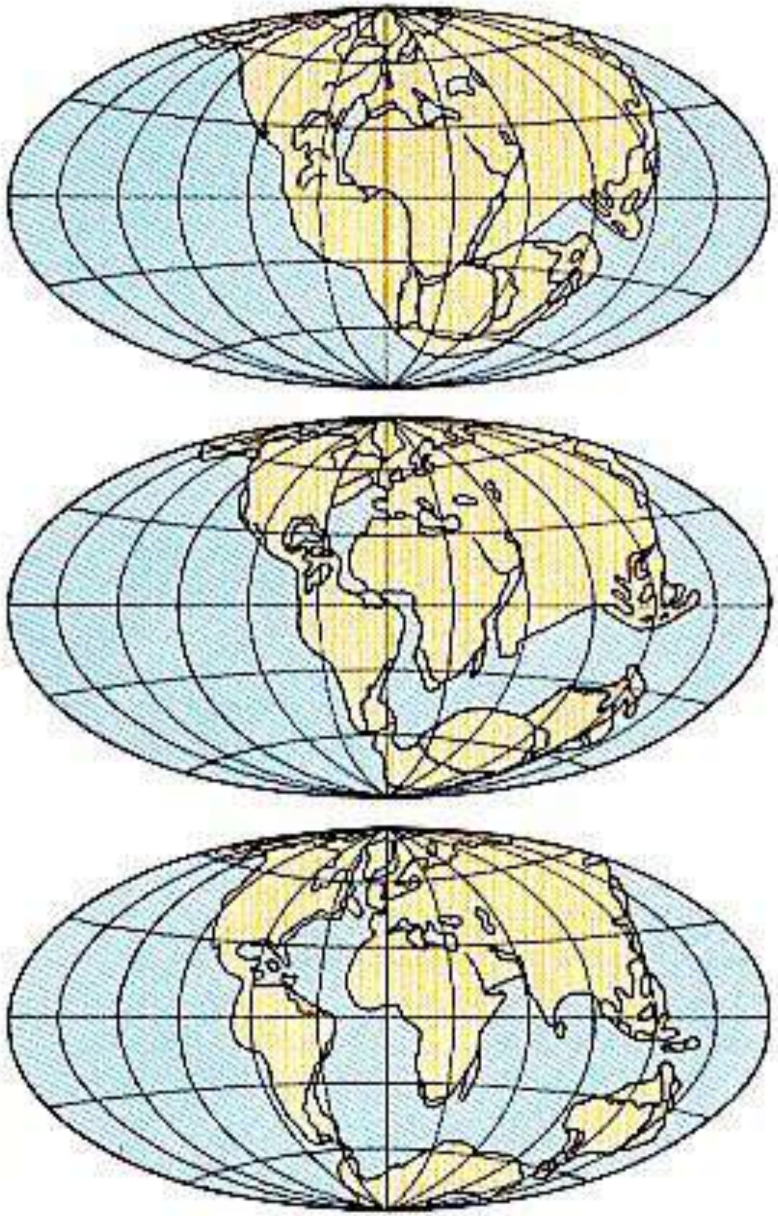
- Plates move over the asthenosphere
  - as a result of underlying *convection cells*

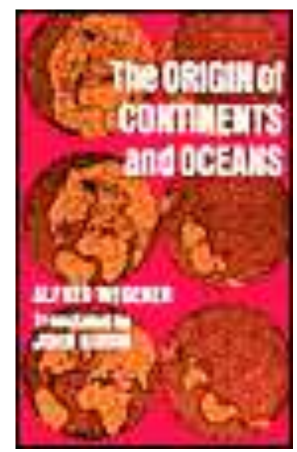
Continental Drift



Antonio Snider-Pelligrini' Map (1858)

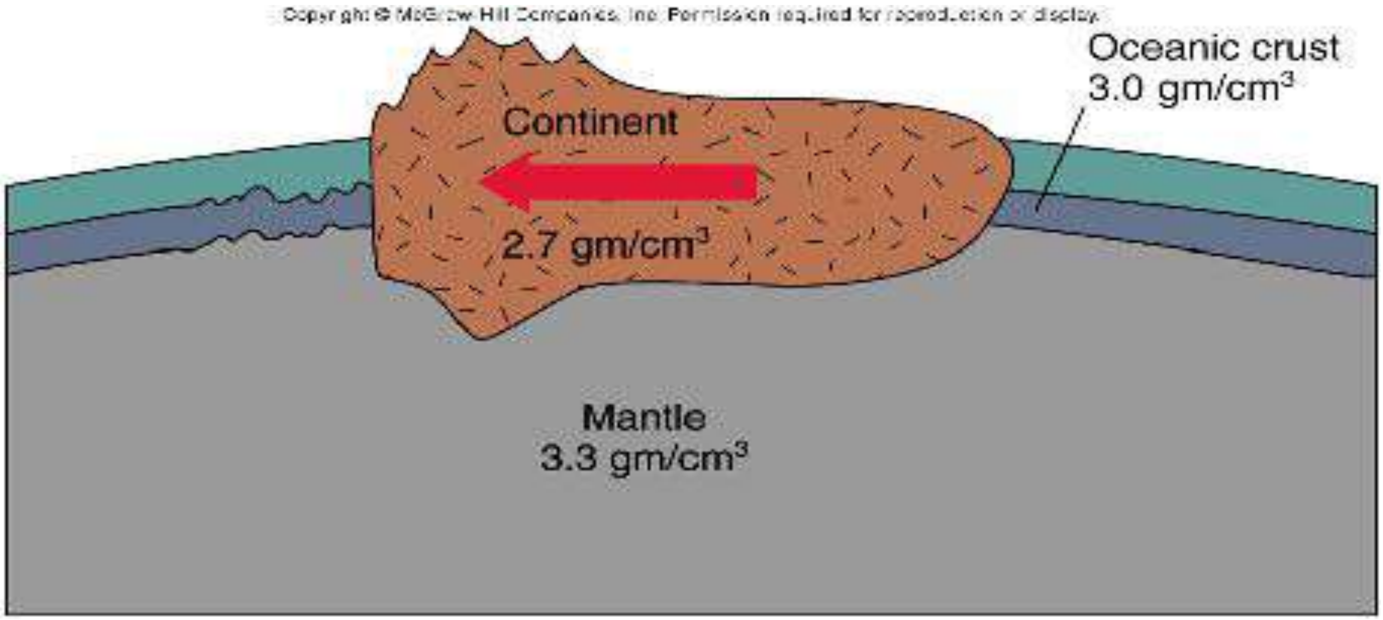
Continental Drift





Alfred Wegener' Map (1915)

Continental Drift

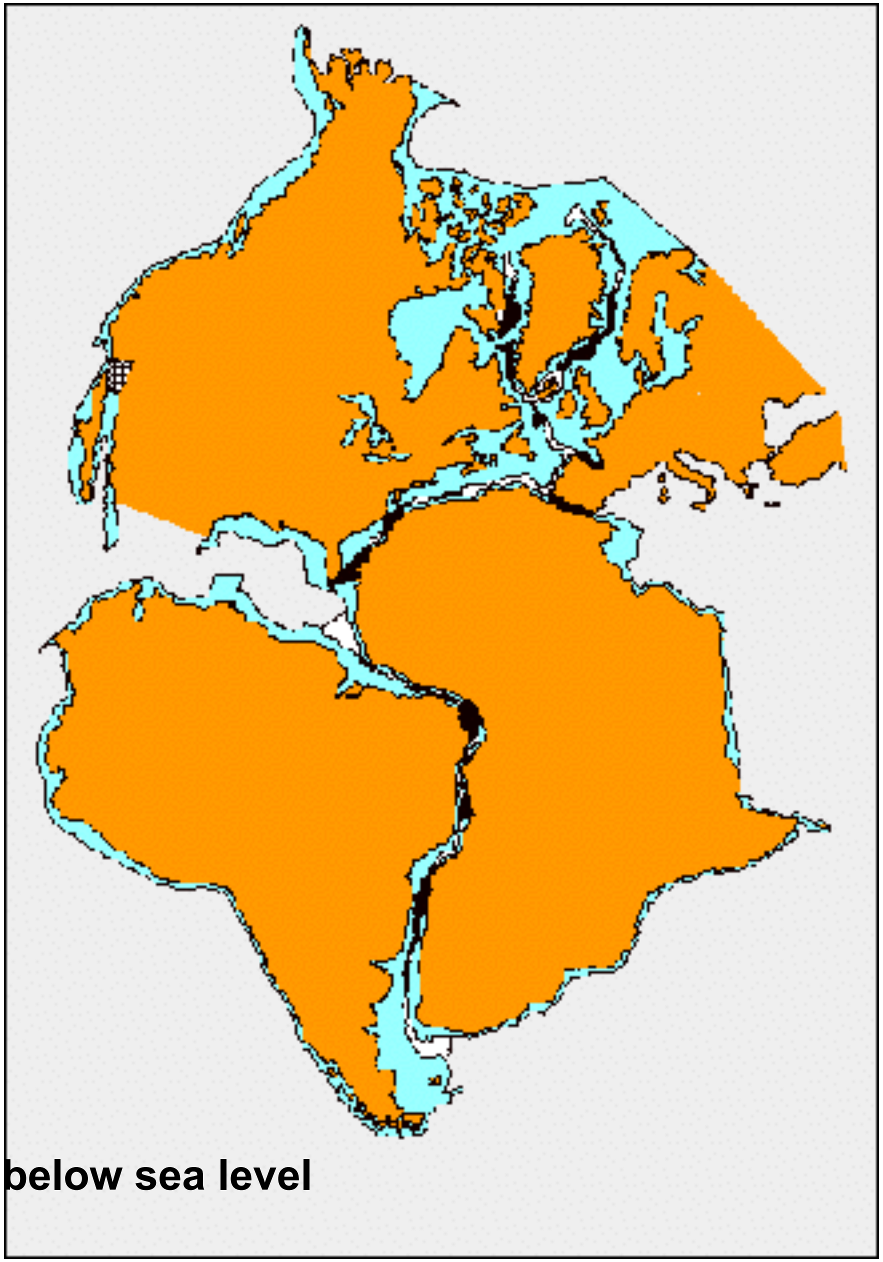


Wegener's Concept of Continental Drift and Orogenesis

<u>Note:</u>
Most geologists and geophysicists rejected Wegener's ideas because they violated what was known about the STRENGTH OF ROCKS.
Also, centrifugal force (from Earth's rotation) along with tidal forces were deemed to be TOO SMALL to move the continents!

Evidence on Continent

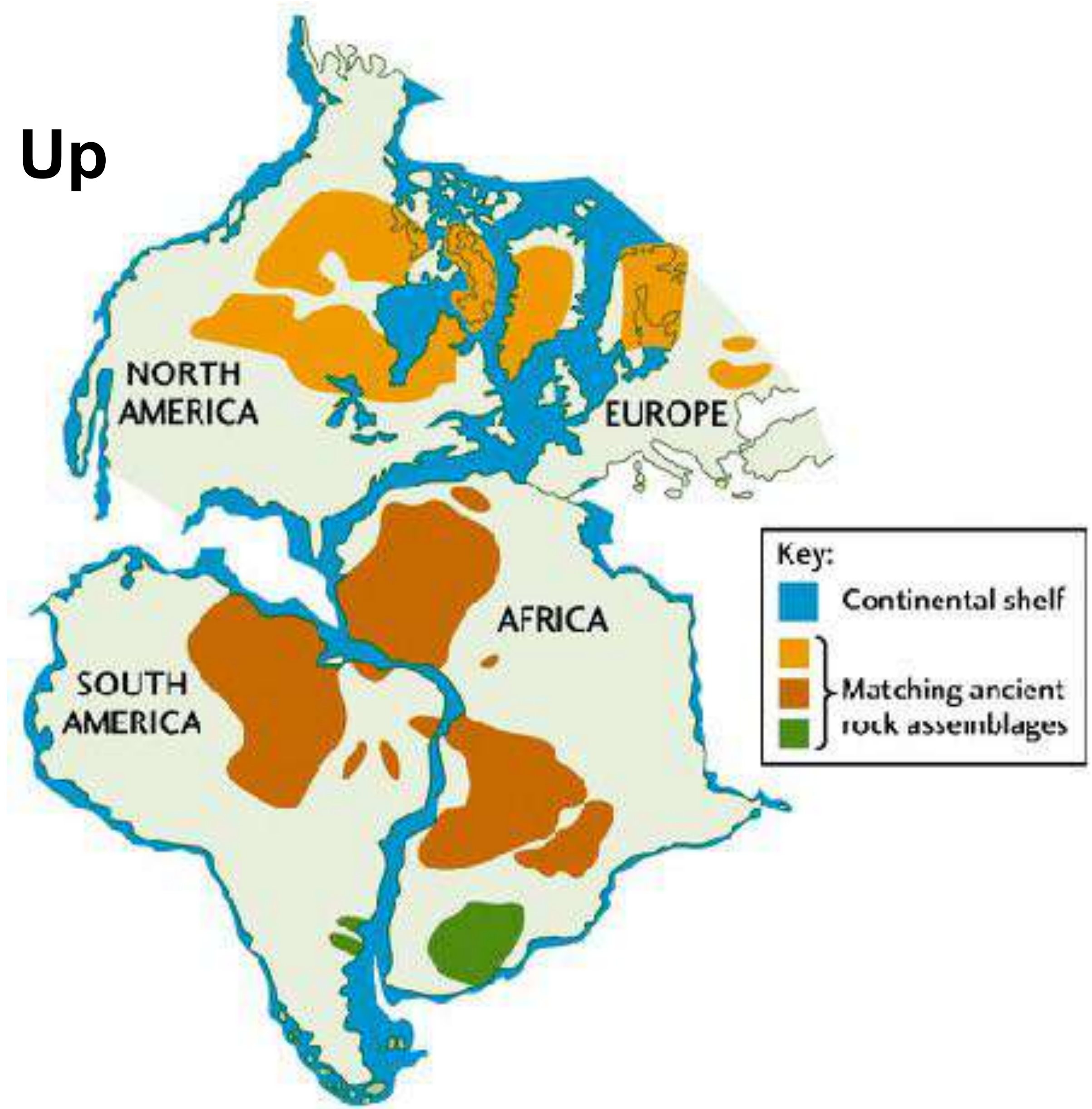
Continents Fit Together



Best fit at 100 m below sea level

Evidence on Continent

Rocks and Structures Match Up



Evidence on Continent

Mountain Belts of the Same Age

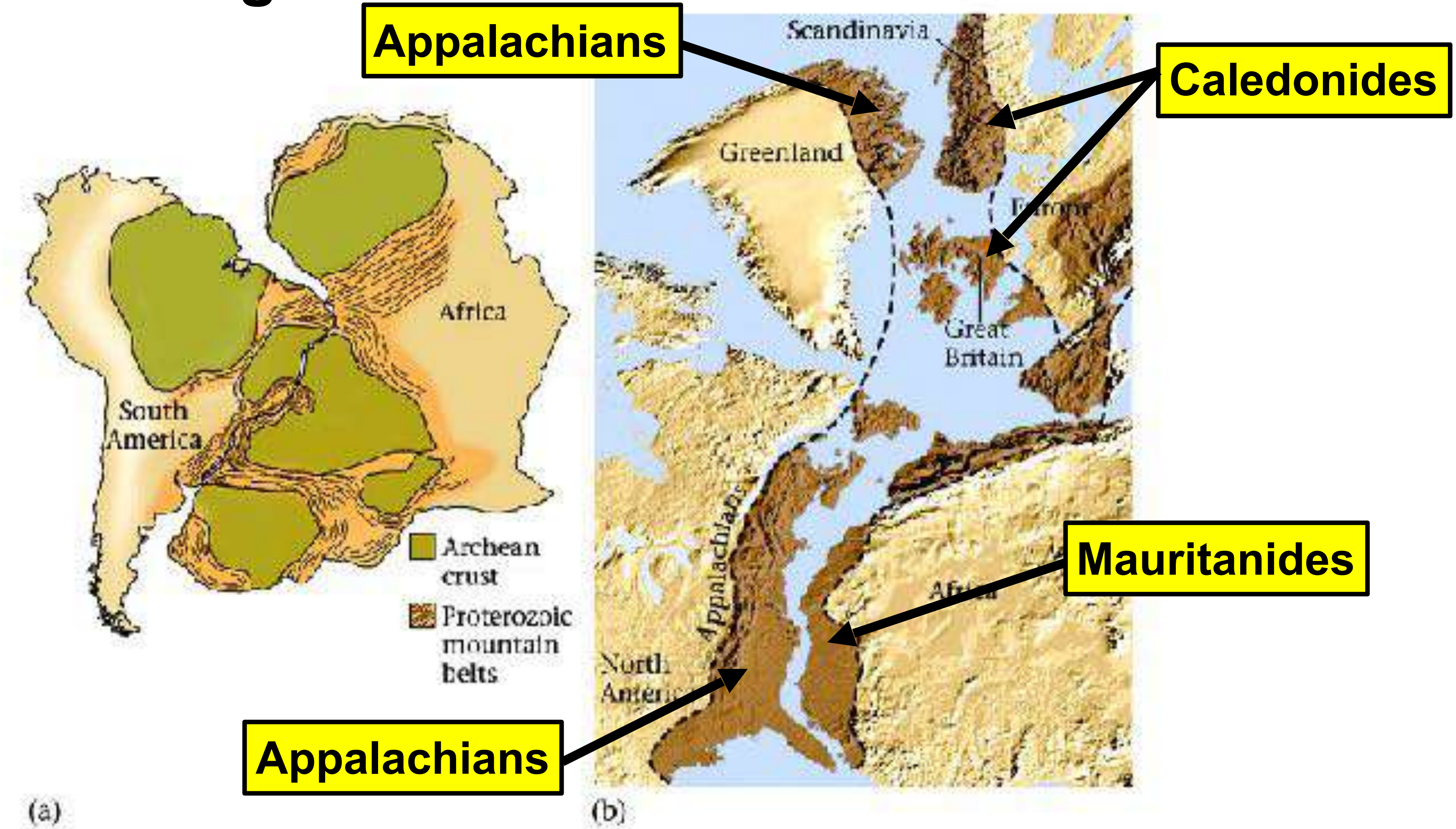


FIGURE 3.6

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Evidence on Continent

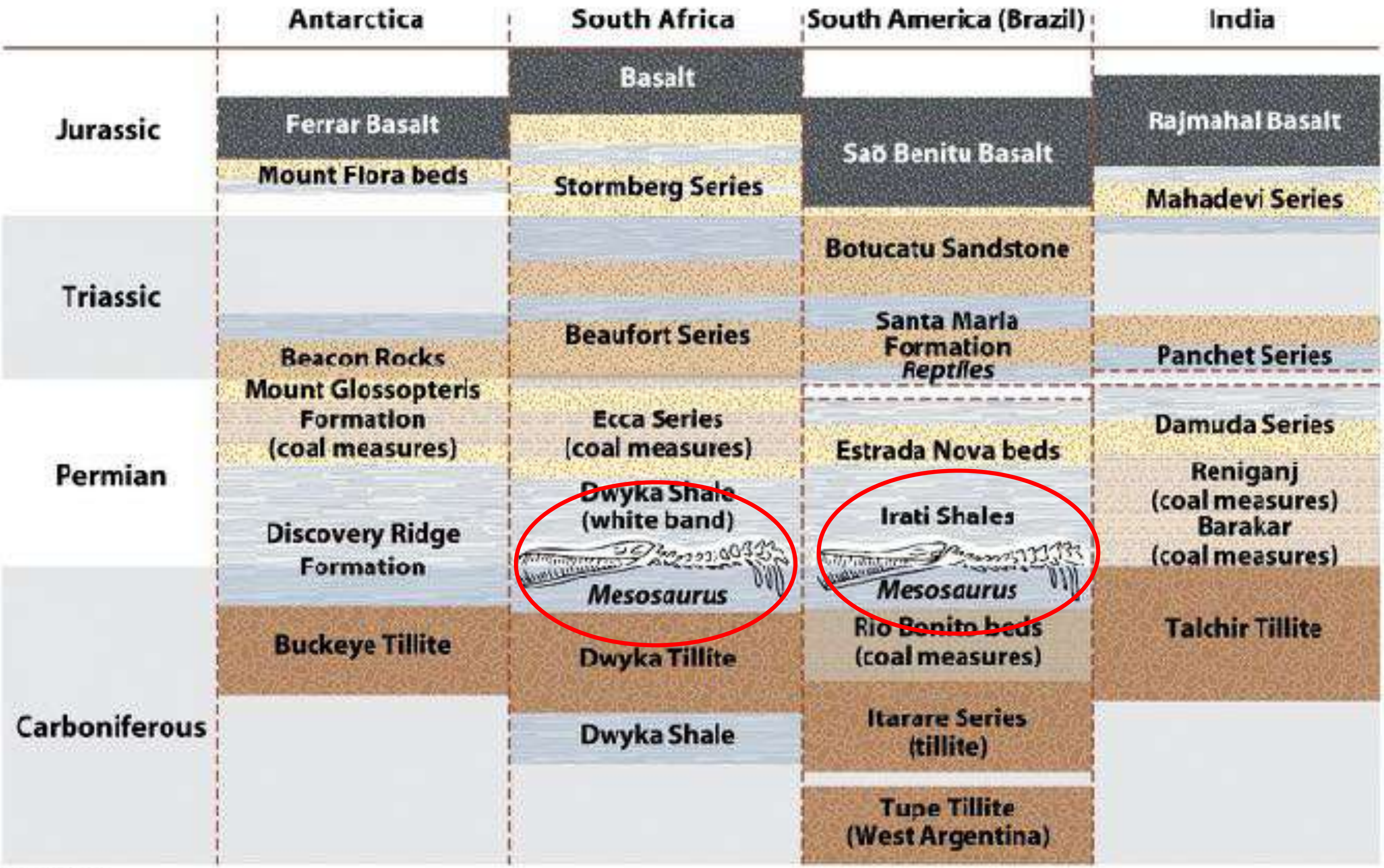


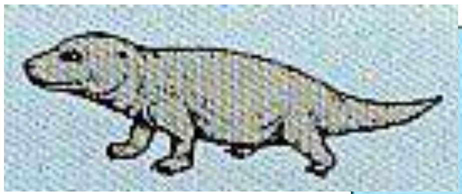
Figure 8-7
Earth System History, Second Edition

Evidence on Continent

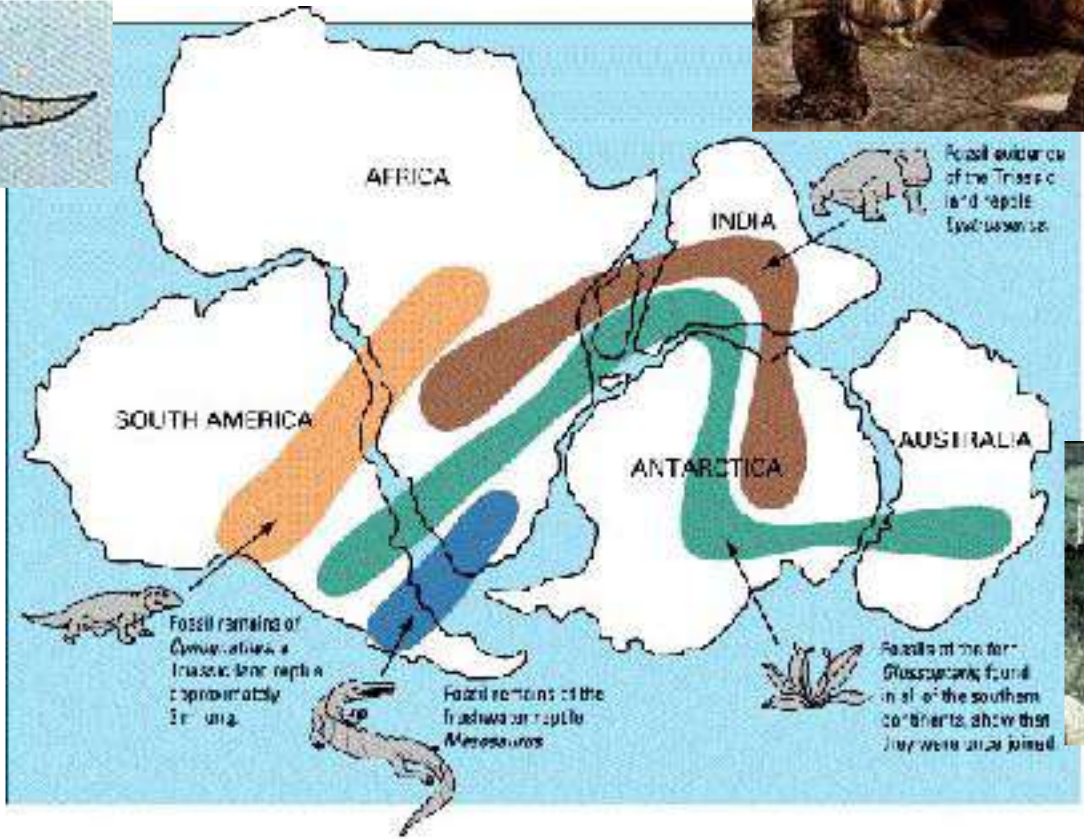
Fossils

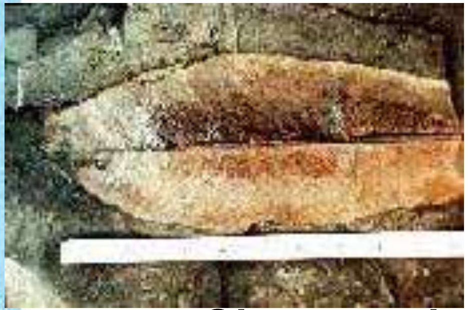
Early Triassic

Lystrosaurus

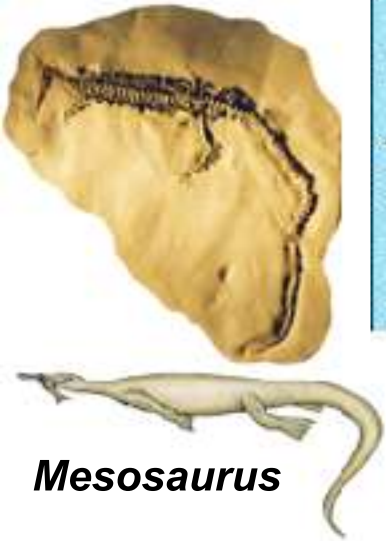


Cynognathus





Glossopteris



Mesosaurus

Permian

Permian-Pennsylvanian

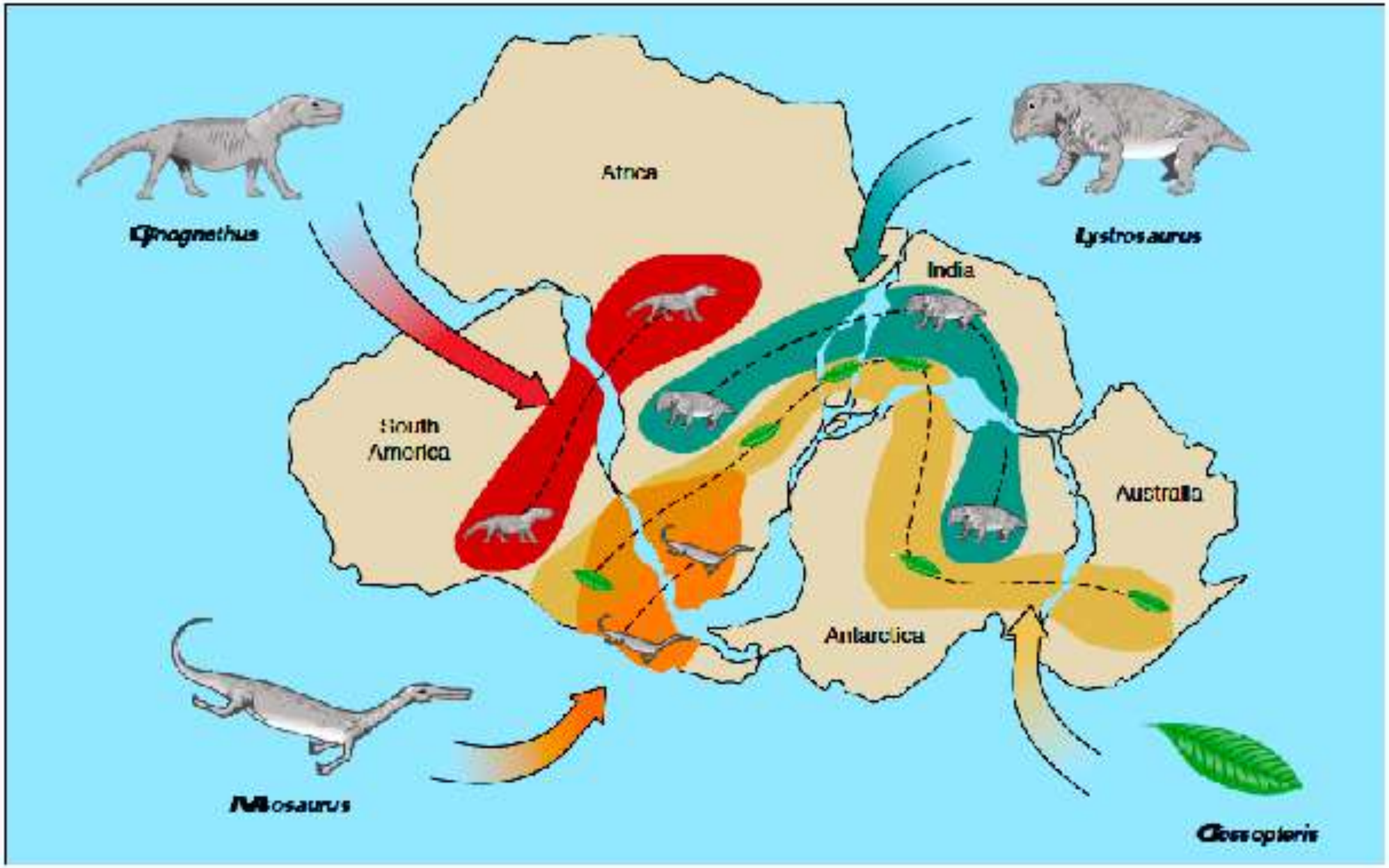
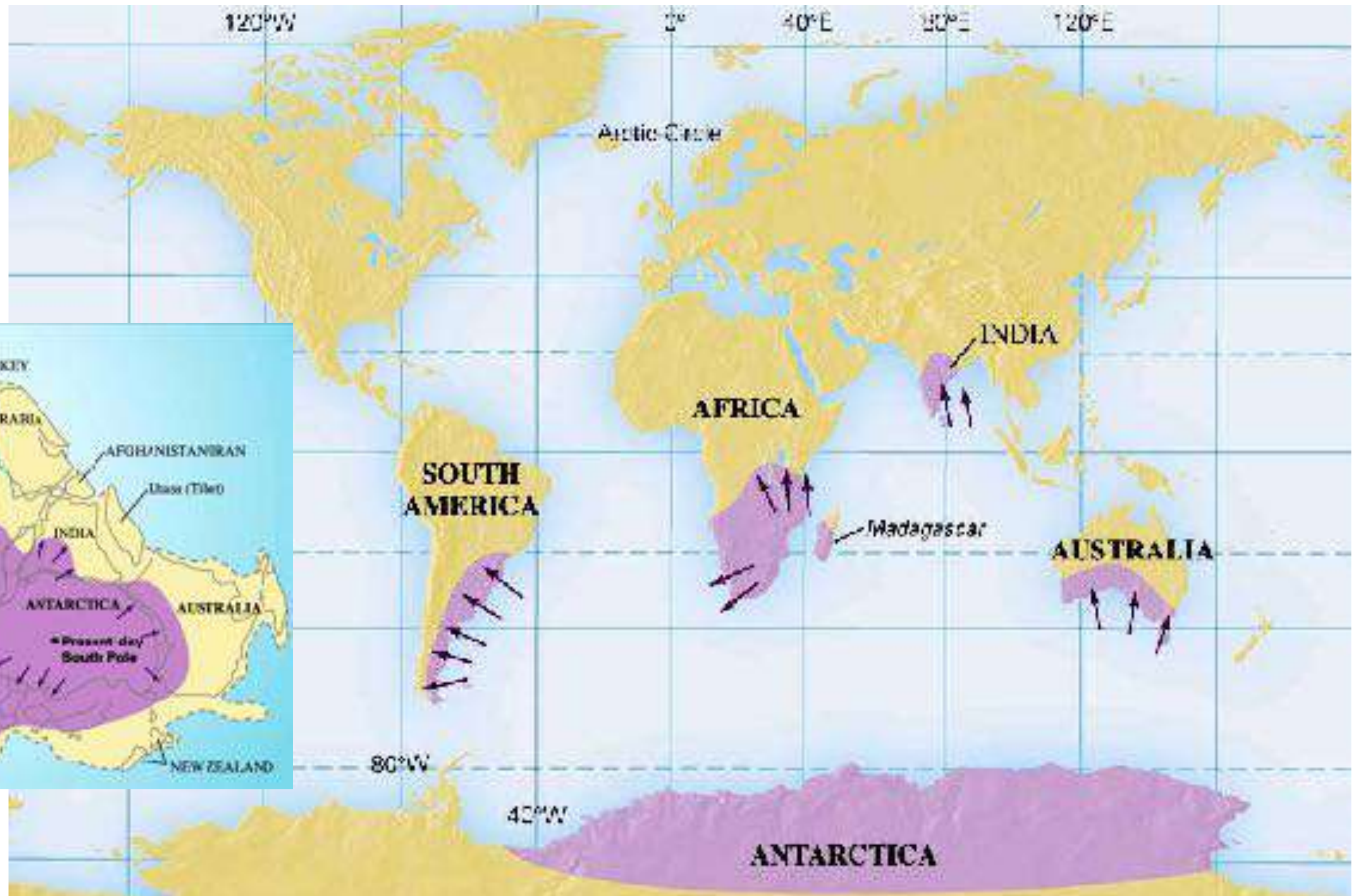


FIGURE 4.3

Distribution of plant and animal fossils that are found on the continents of South America, Africa, Antarctica, India, and Australia give evidence for the southern supercontinent of Gondwana. *Glossopteris* and other fernlike plants are found in Permian- and Pennsylvanian-age rocks on all five continents. *Cynognathus* and *Lystrosaurus* were sheep-sized land reptiles that lived during the Early Triassic Period. Fossils of the freshwater reptile *Mesosaurus* are found in Permian-age rocks on the southern tip of Africa and South America.

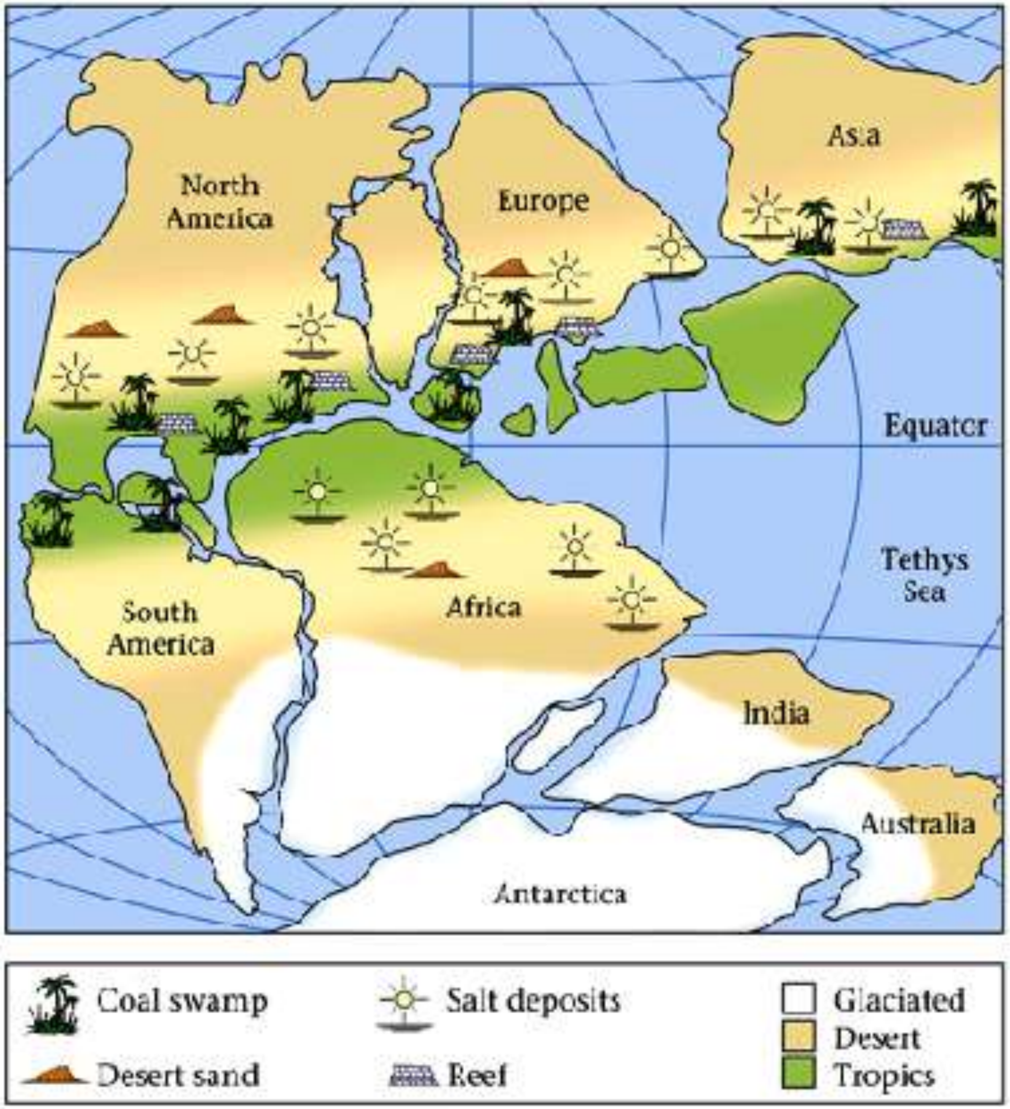
Evidence on Continent

Glacial Features



Evidence on Continent

Paleoclimate of Pangea



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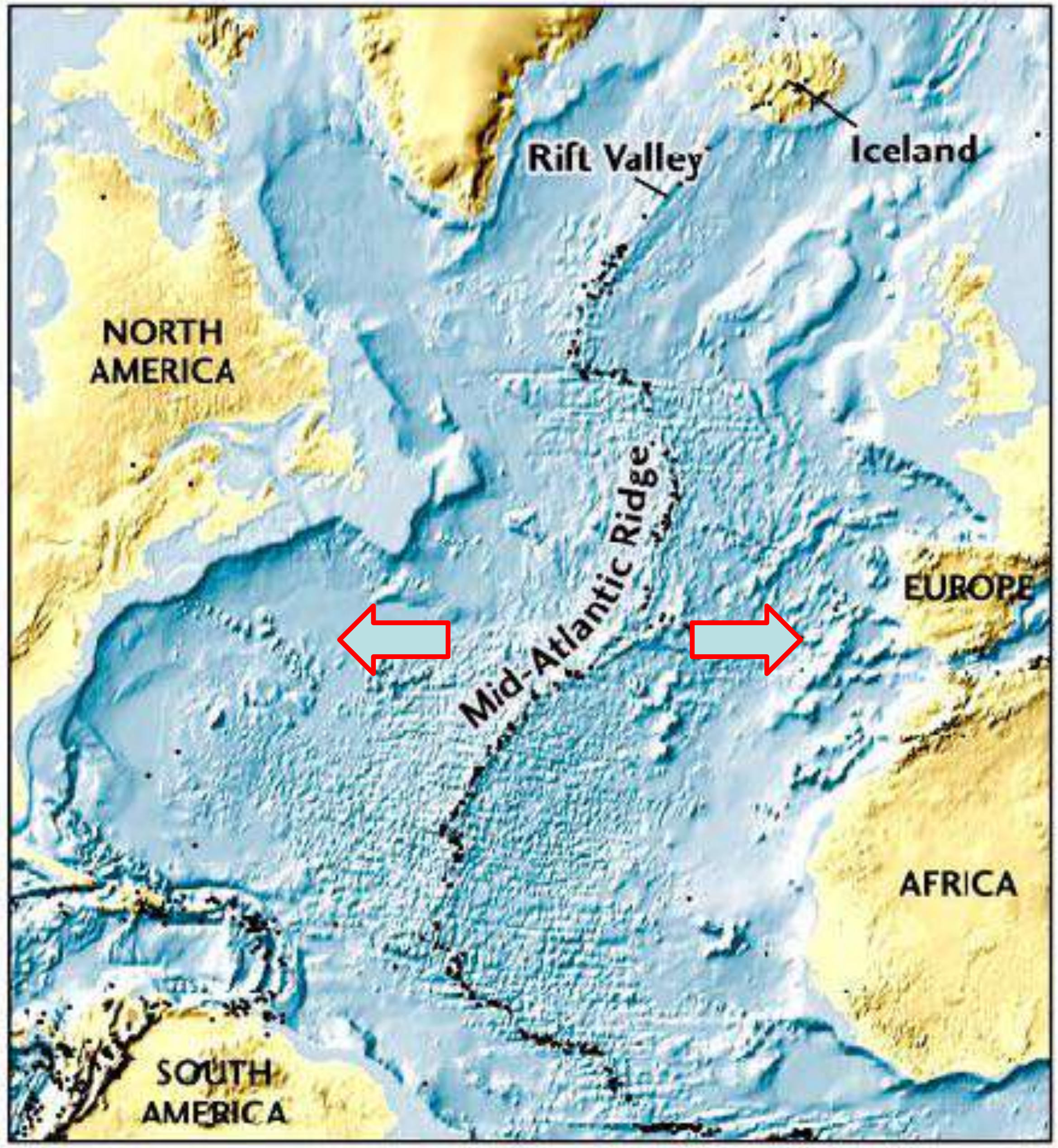
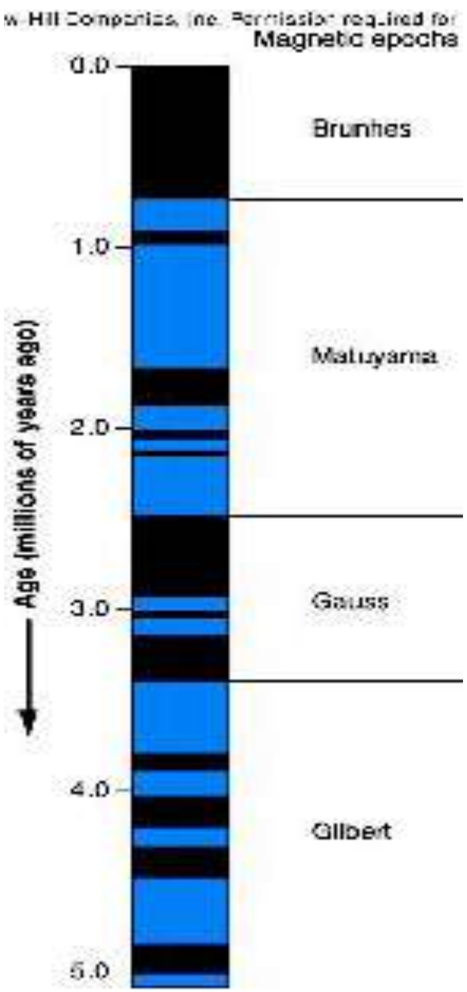
Evidence on Seafloor

Seafloor Morphology :
Indicating seafloor spreading

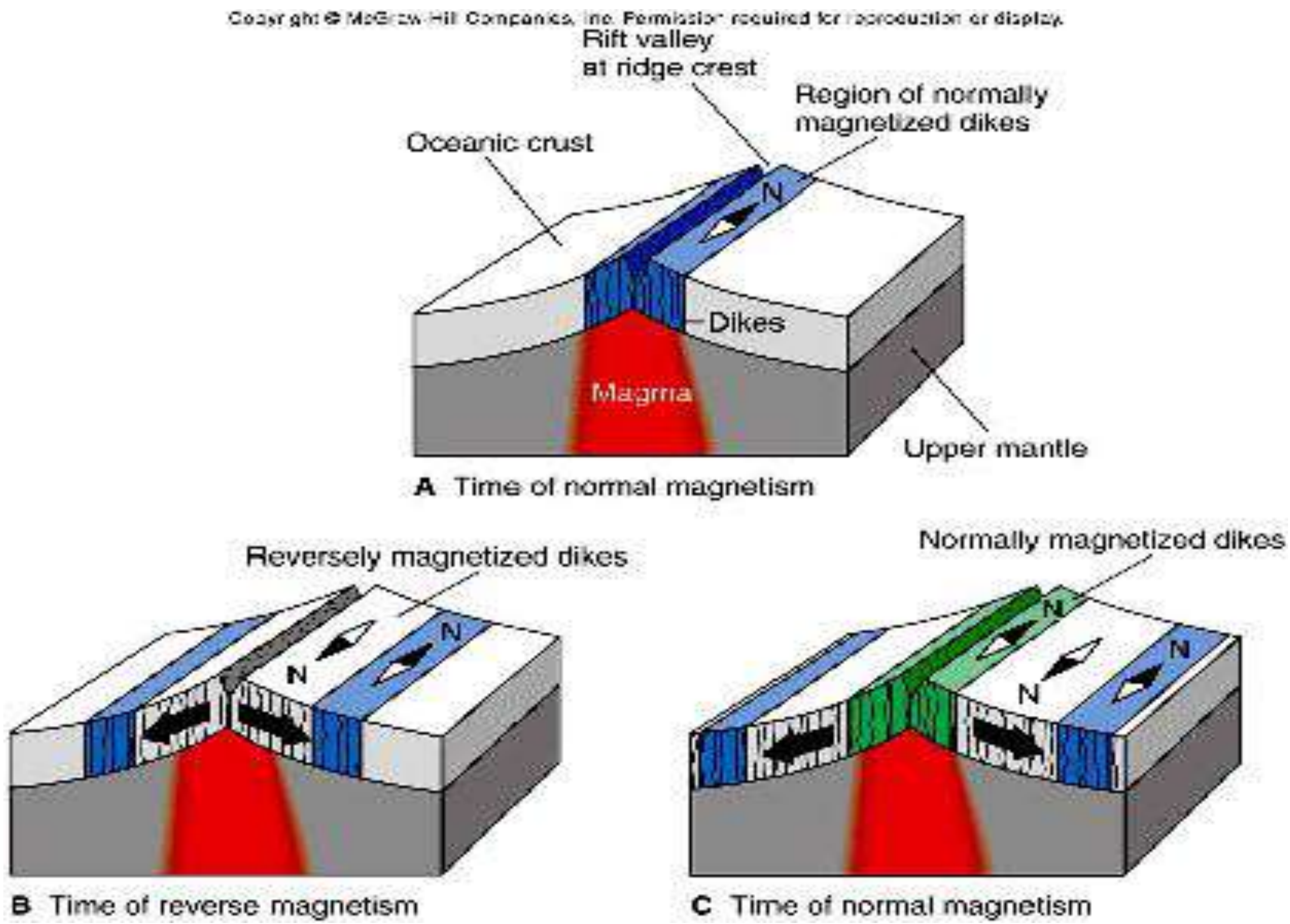


Evidence on Seafloor

Paleomagnetism & seafloor spreading



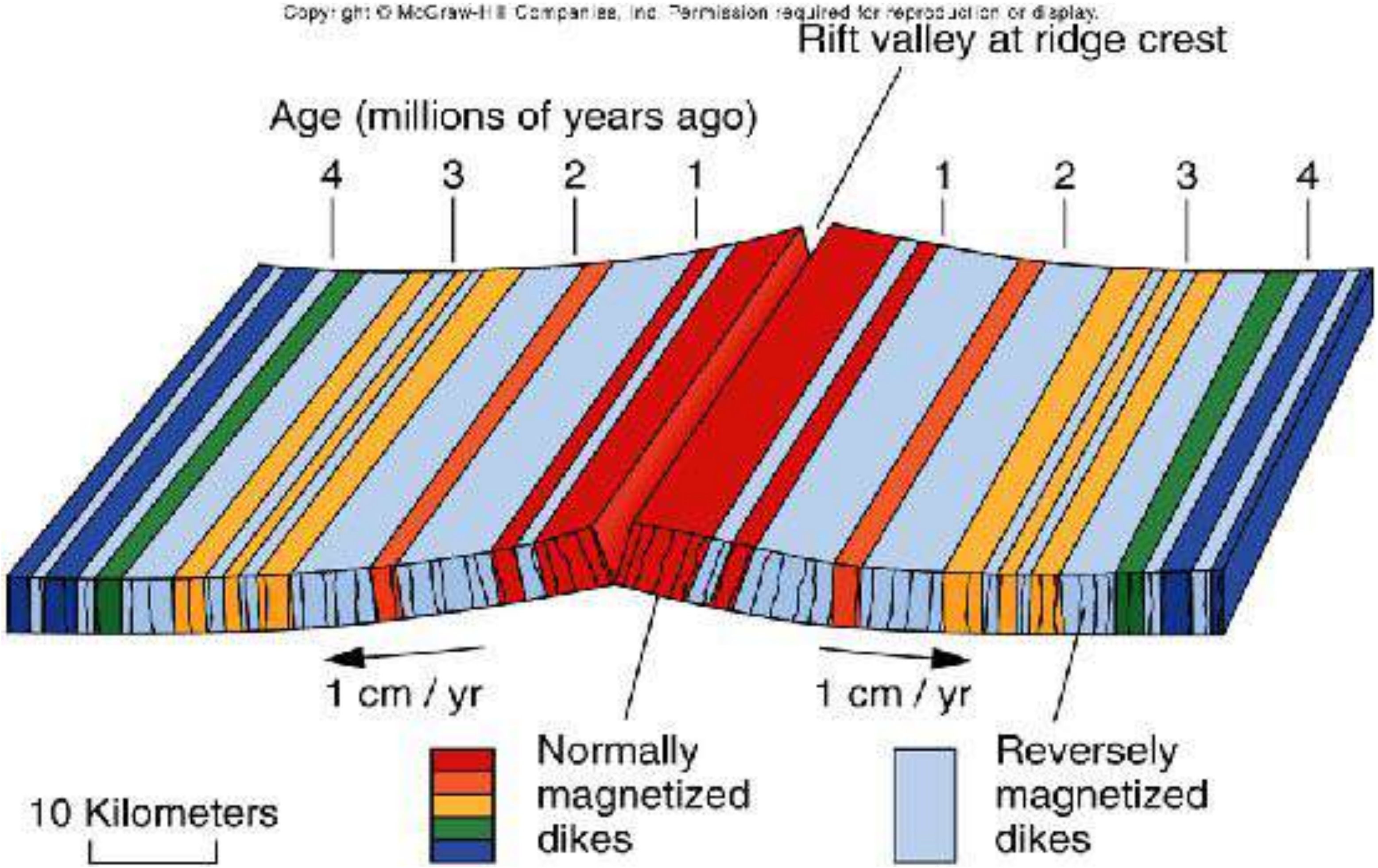
Magnetic Time Scale



Magnetic Stripe Formation at Ridge Crest

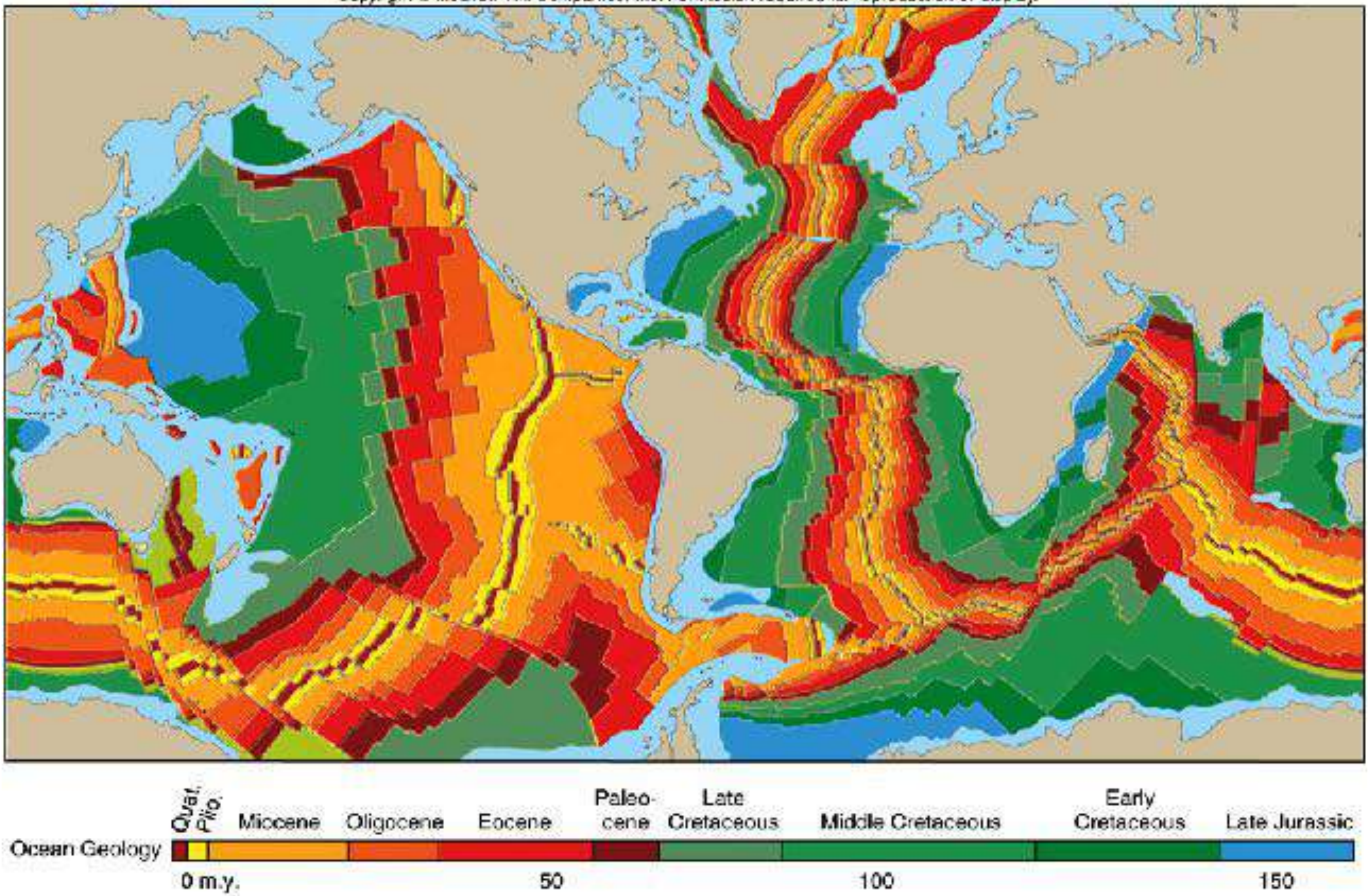
Evidence on Seafloor

Paleomagnetism & seafloor spreading



Evidence on Seafloor

Seafloor Age Map



Evidence on Seafloor

Mantle Plume Hot Spot Tracks

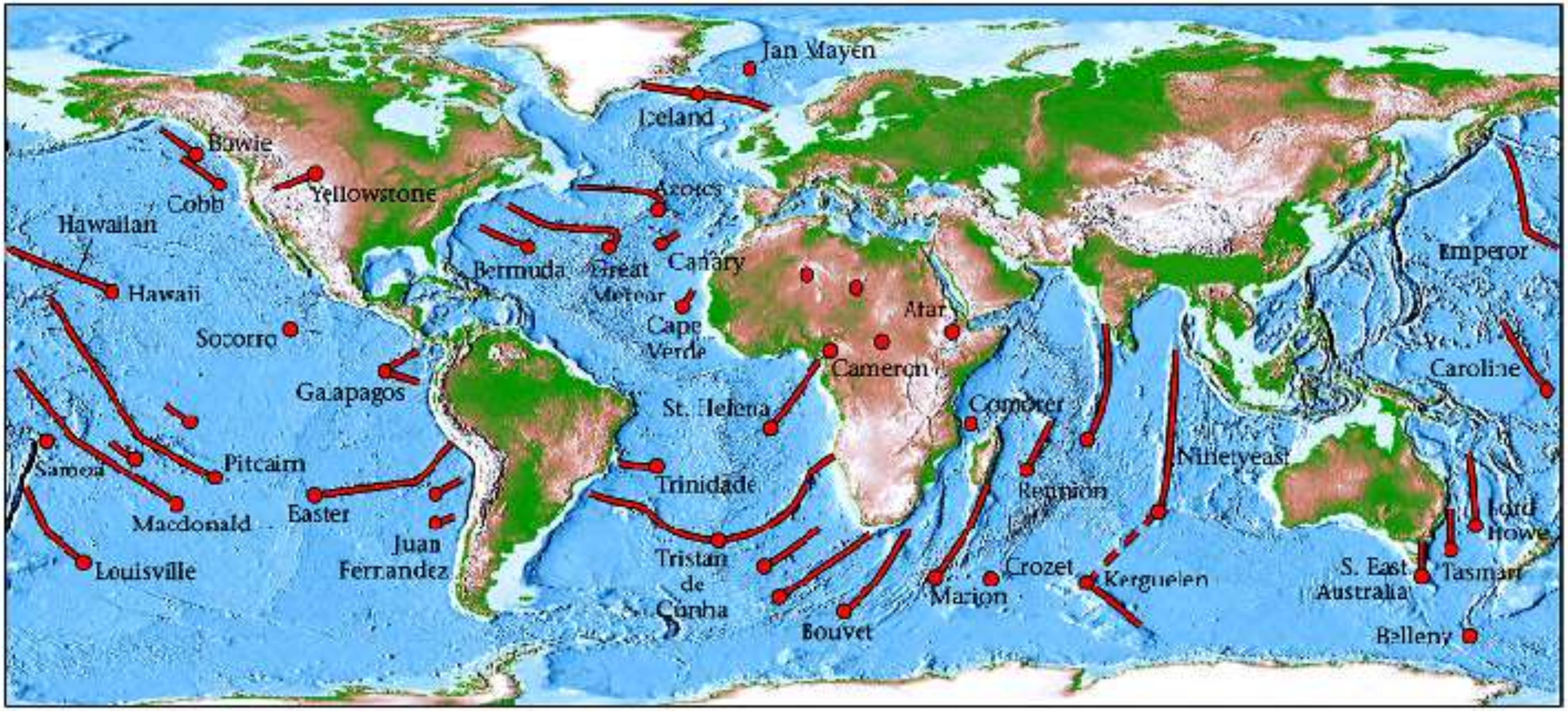
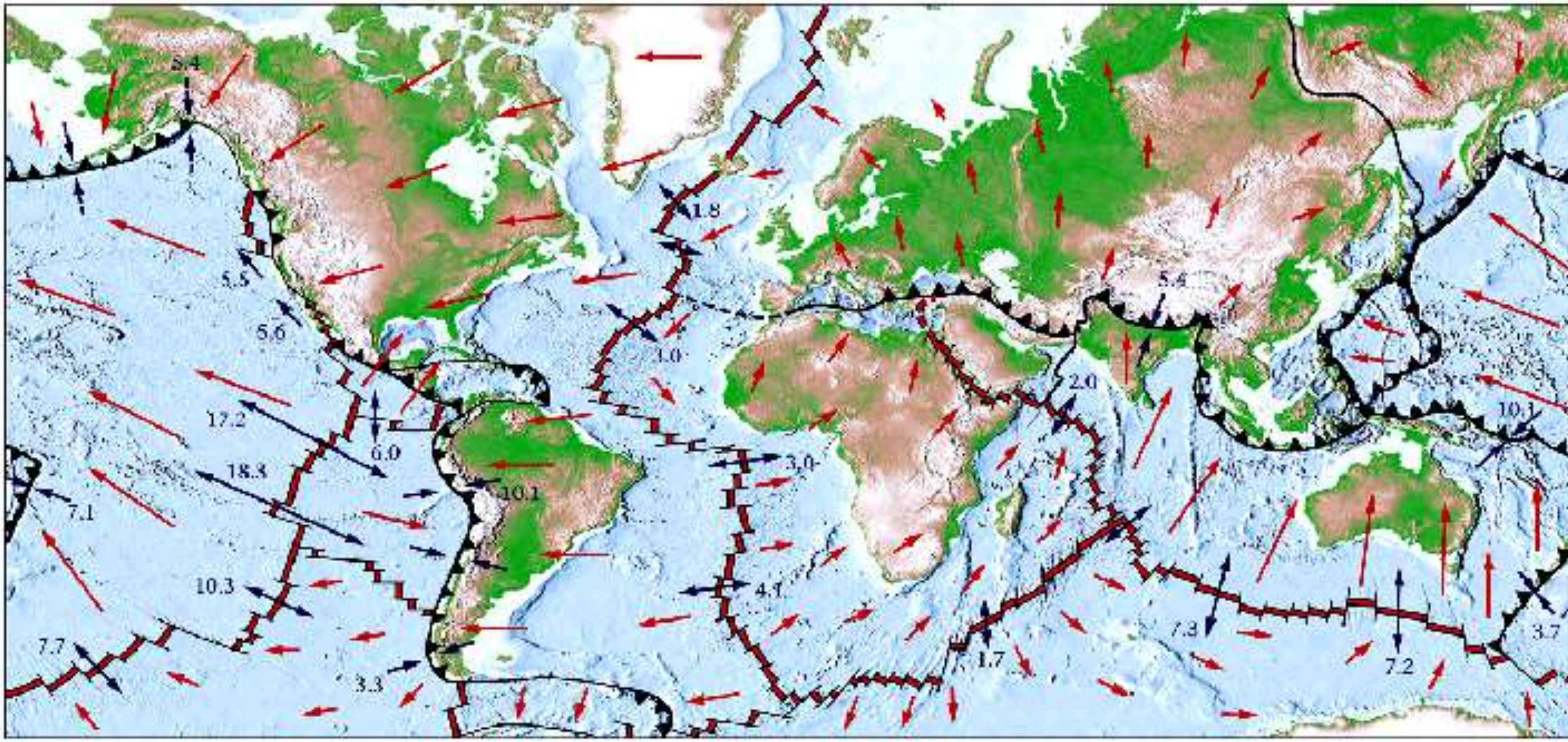


FIGURE 4.21 *Earth: Portrait of a Planet*, 2nd Edition

Plate Tectonics

Directions of Motion and Plate Velocities
Determined by Mantle Plume Hot Spot Tracks and Age-Dating of Rocks



▲▲▲ Convergent boundary — Ridge — Transform — Absolute plate motions — Relative plate motions (5.5 cm per year)

FIGURE 4.30 *Earth: Portrait of a Planet*, 2nd Edition

Plate Tectonics

Directions of Motion and Plate Velocities Determined by GPS (Global Positioning System) Satellites

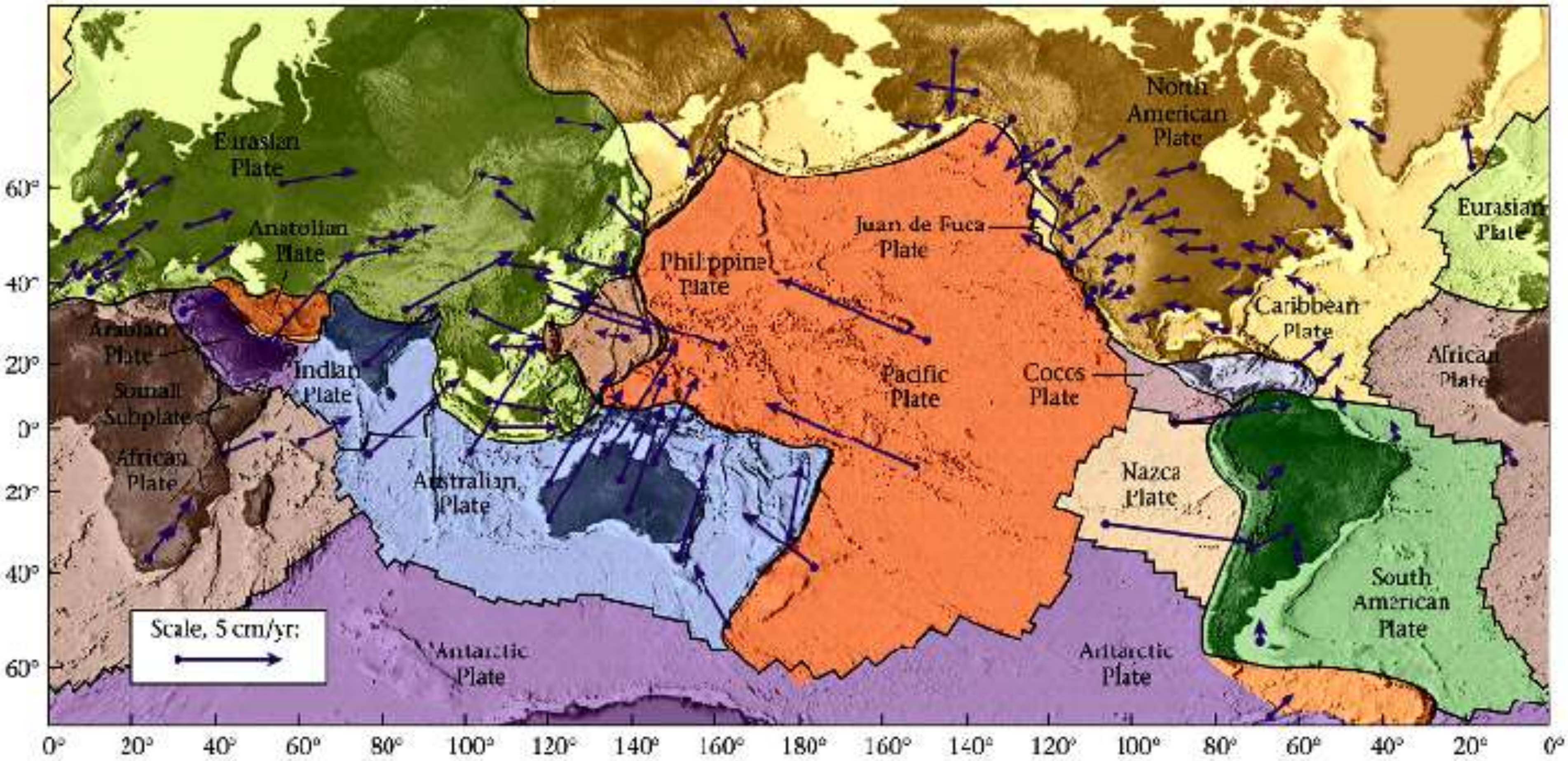


FIGURE 4.31 *Earth: Portrait of a Planet*, 2nd Edition

Reconstruction

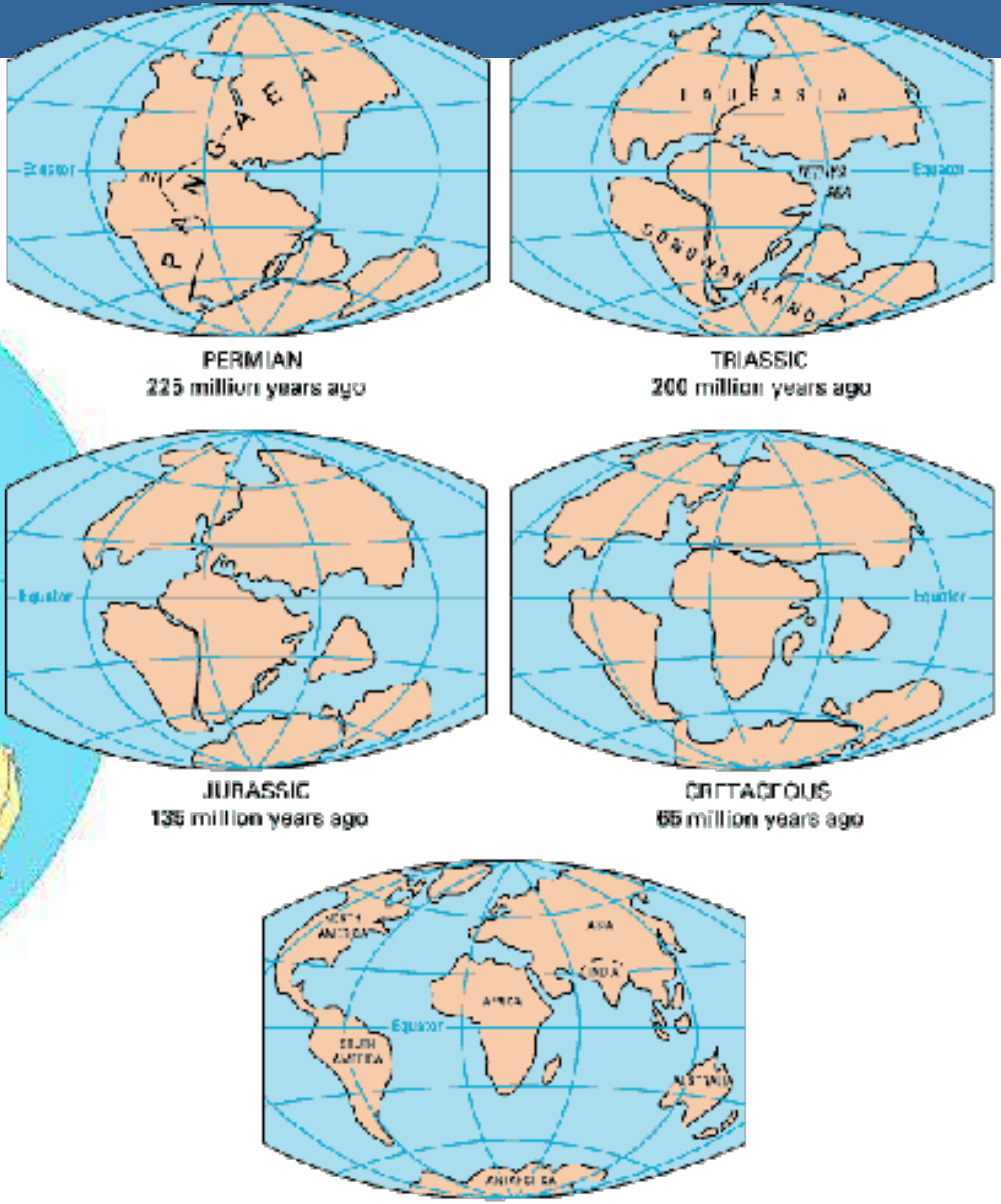
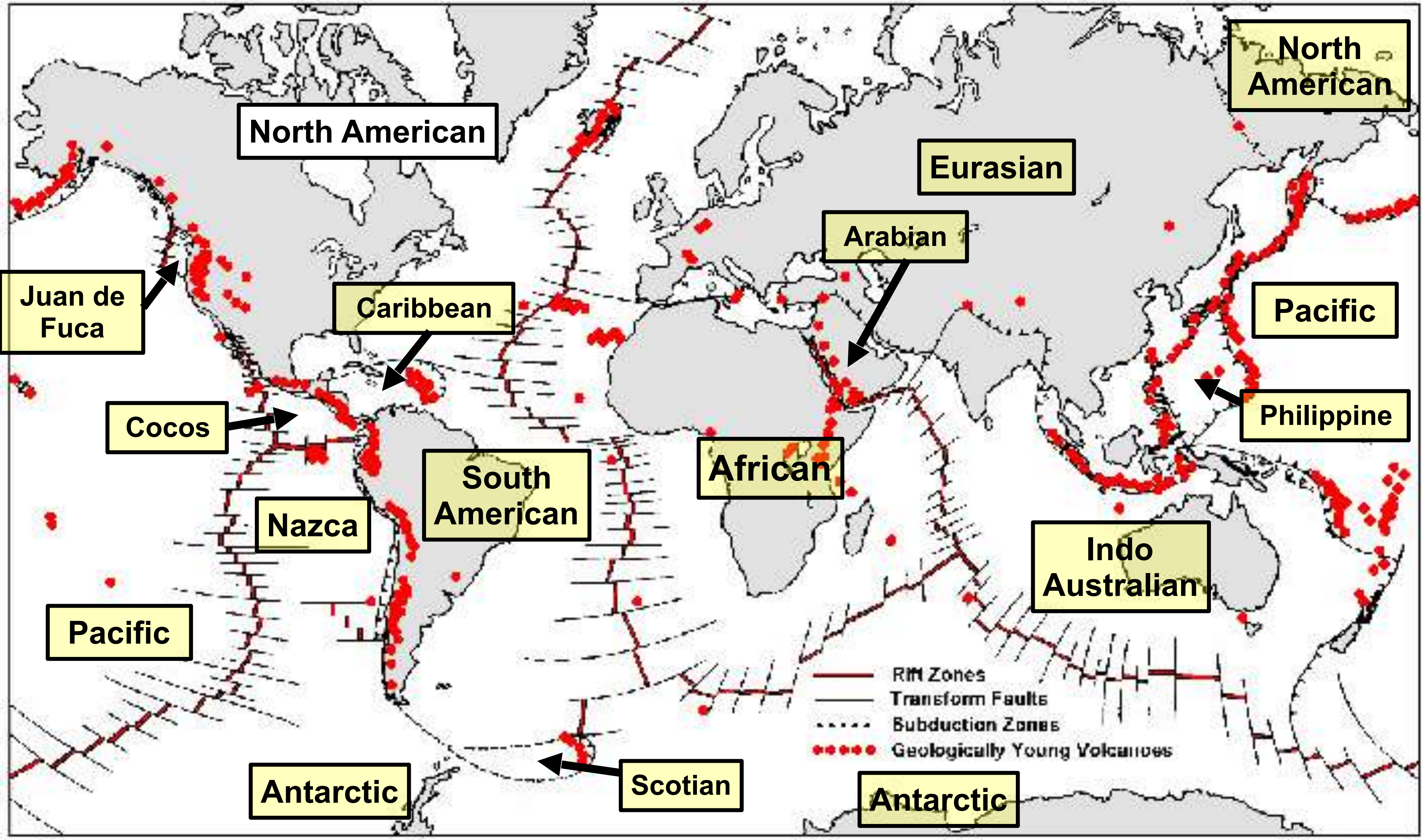


Plate Tectonics

Earth's Tectonic Plates

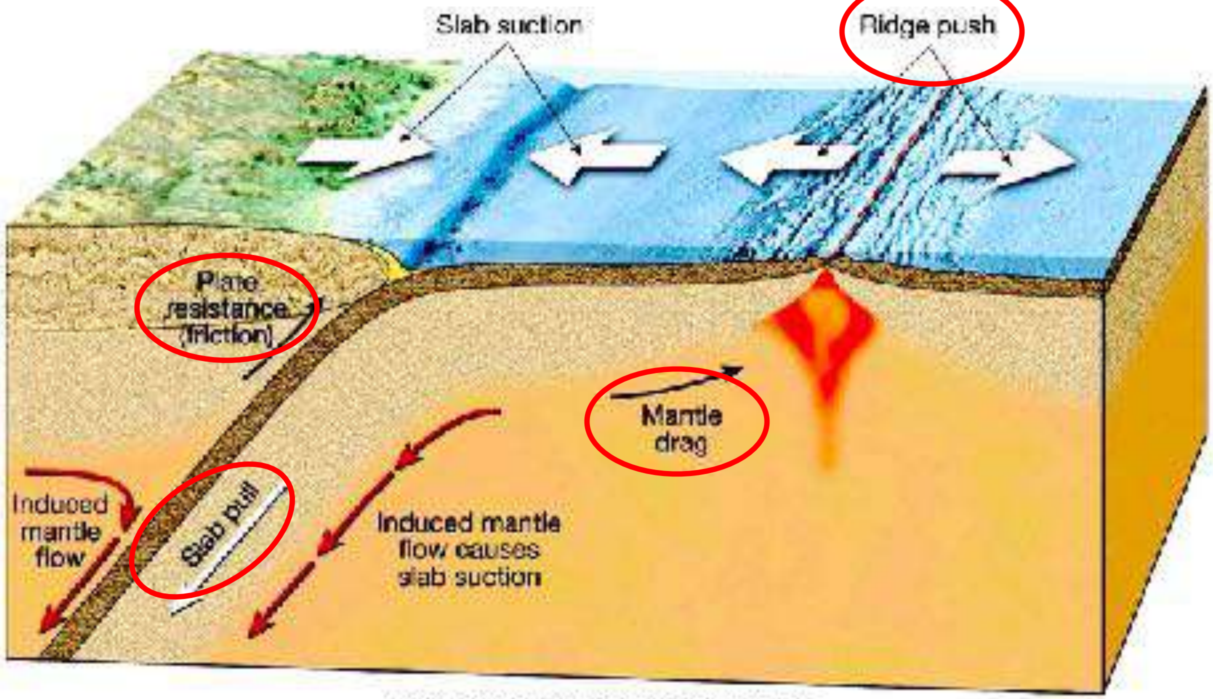


What drives Plate Tectonics?

What drives plate motions

RIDGE-PUSH

- The higher elevation of spreading centers result in oceanic lithosphere wanting to move "downhill", away from the ridge
- Far less important than slab-pull

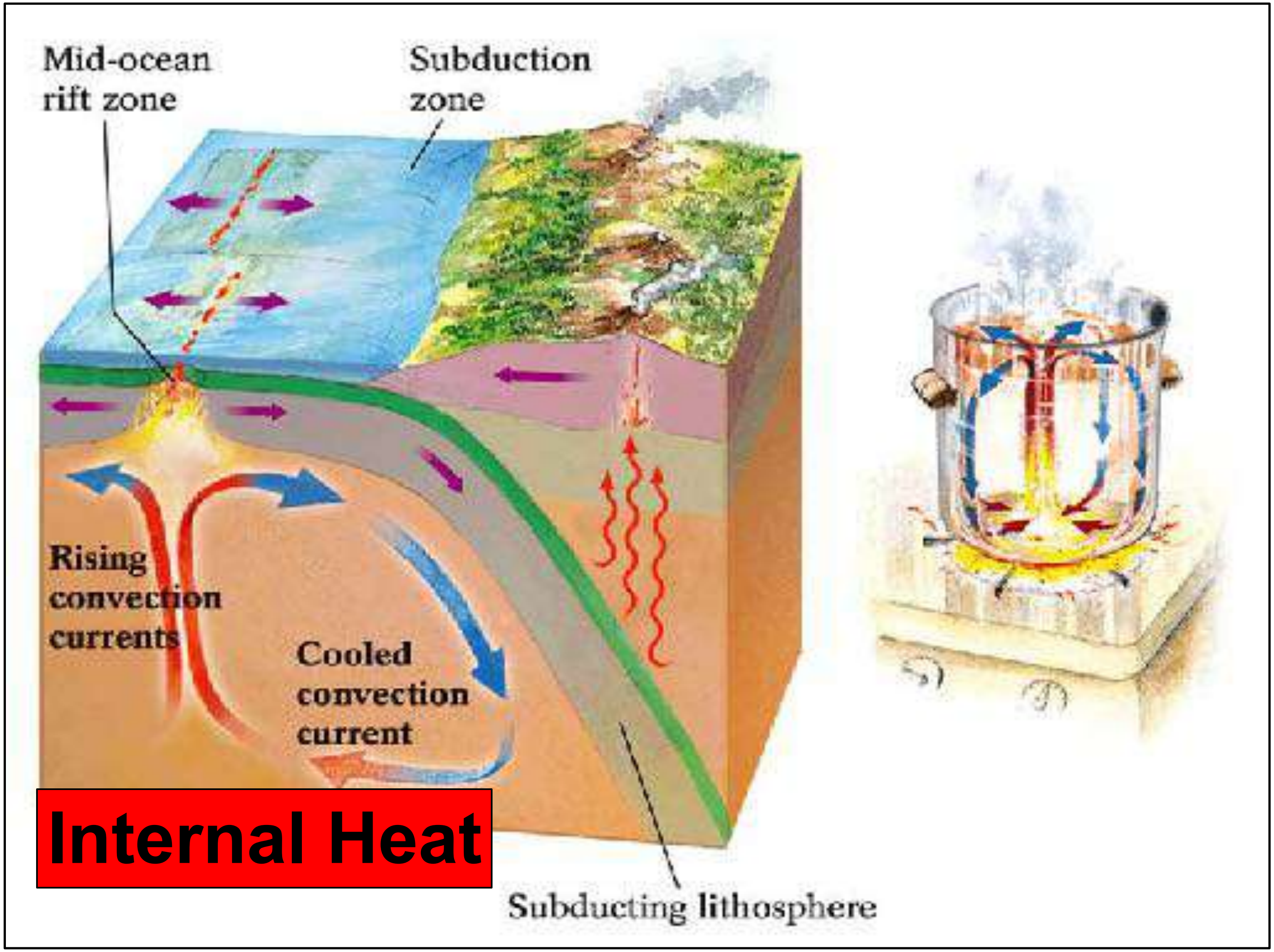


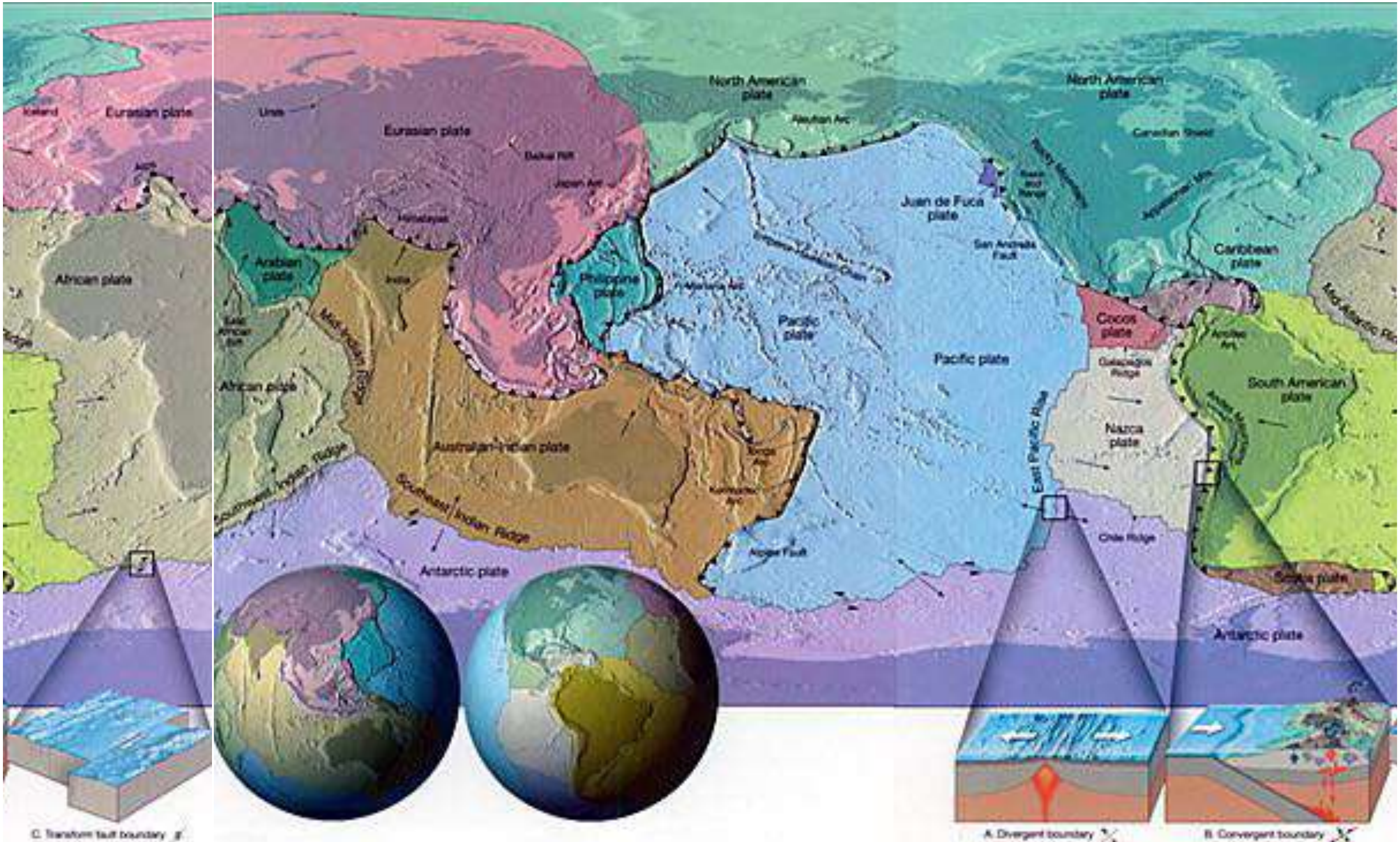
SLAB PULL
Cold, dense slabs of subducted oceanic lithosphere pull the plate towards the subduction zone

MANTLE DRAG and PLATE RESISTANCE
Can act to increase or decrease plate motion

- **Forces that drive plate motion**

Plate Tectonics





3 plate interactions:

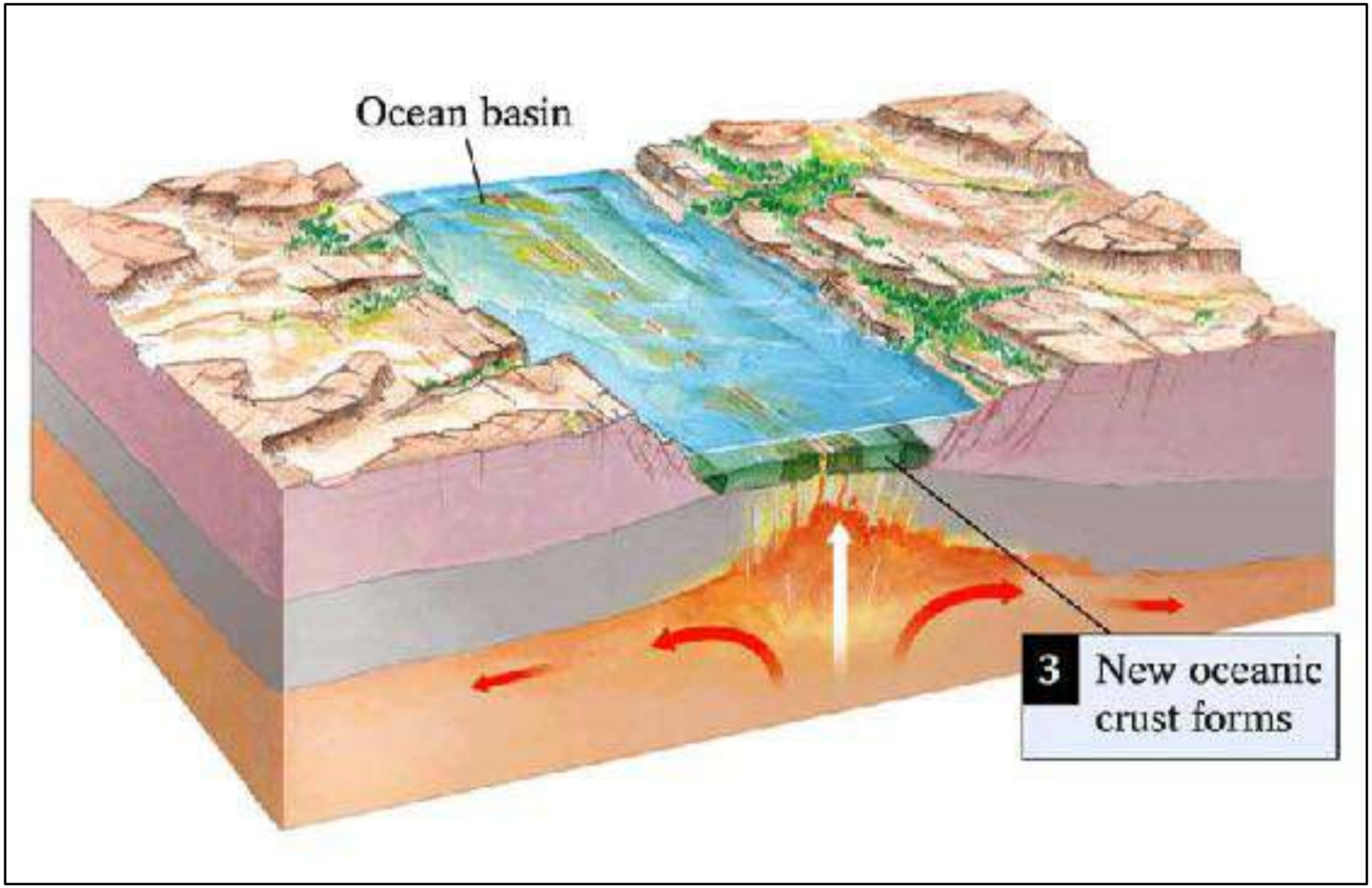
Divergent

Convergent

Transform

Plate Tectonics

Divergent Boundary



Results in the formation of Oceanic Crust

Plate Tectonics

Transform Boundary

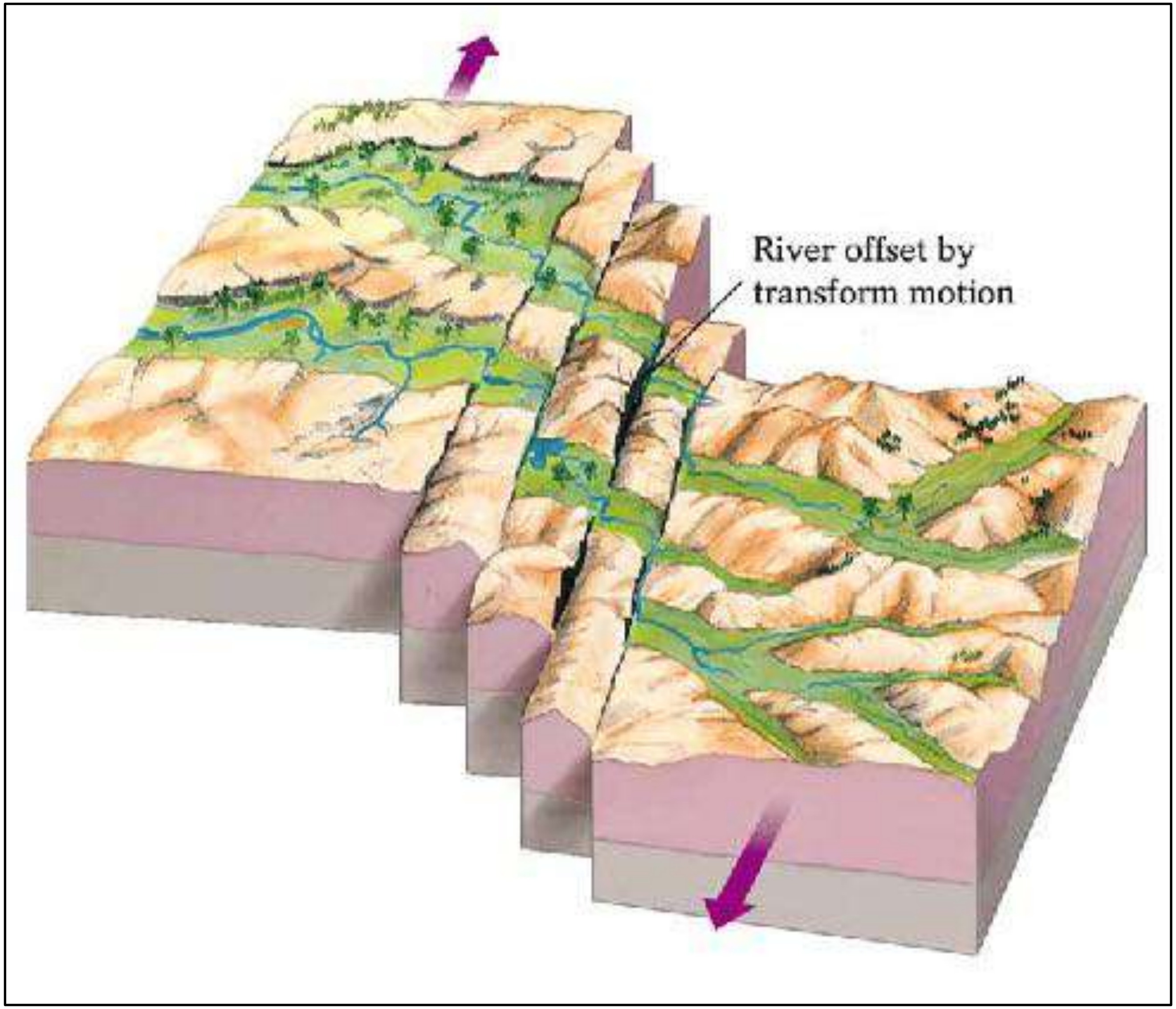
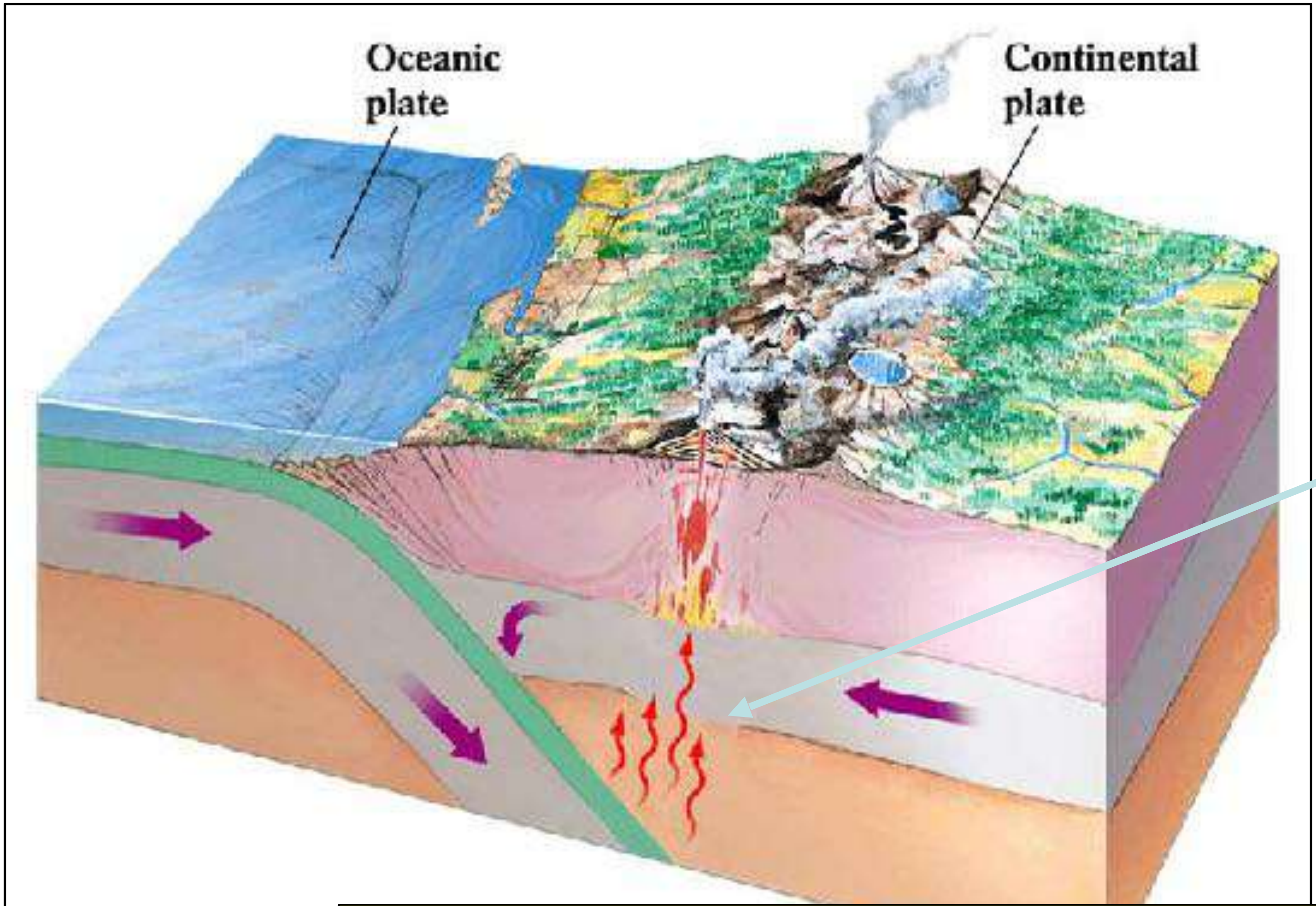


Plate Tectonics

Convergent Boundary: Subduction



Melting Produces More Felsic Magma

Results in the formation & growth of Continental Crust and destruction of Oceanic Crust

OCEAN-OCEAN CONVERGENCE = SUBDUCTION

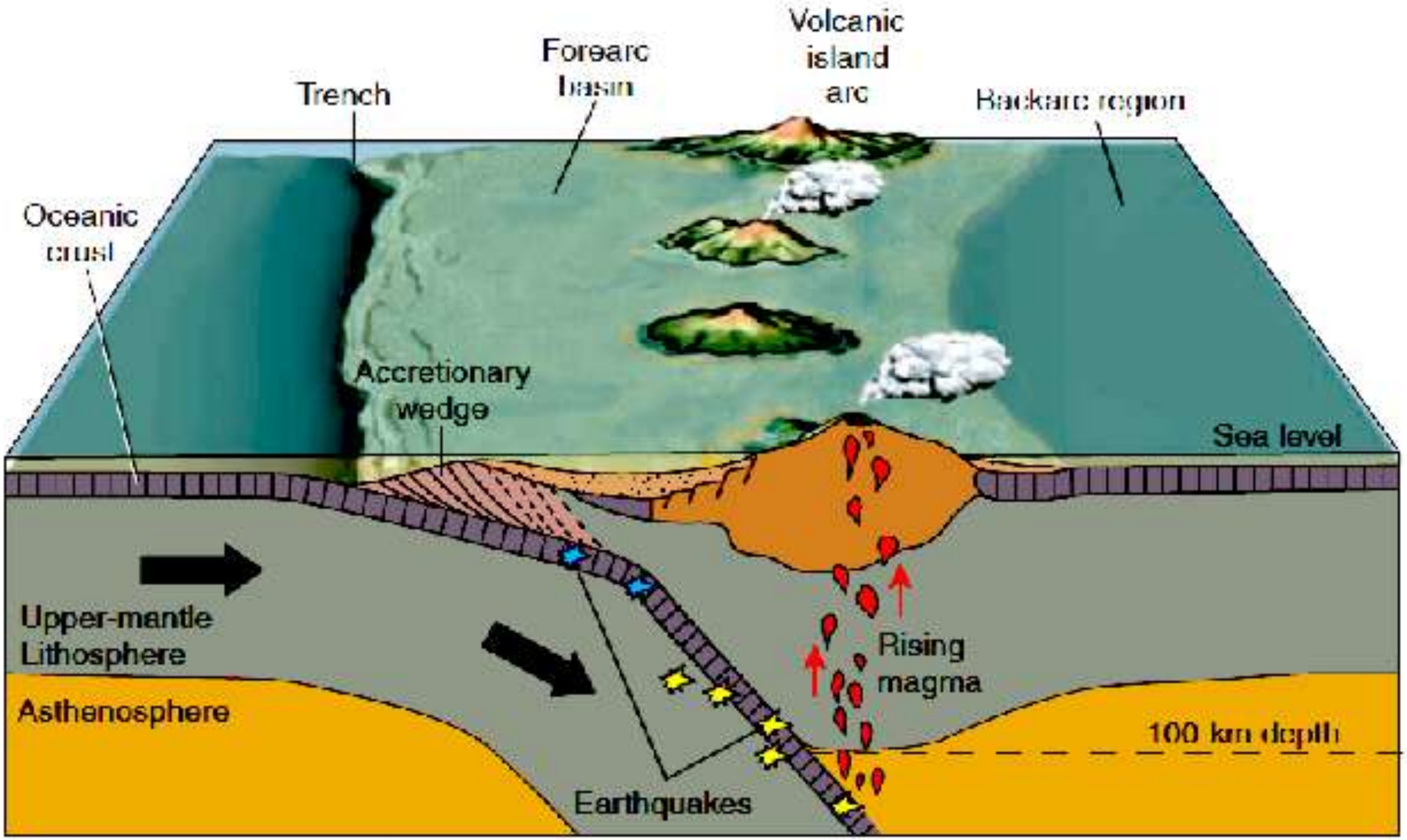


FIGURE 4.25

Ocean-ocean convergence forms a trench, a volcanic island arc, and a Benioff zone of earthquakes.

OCEAN-CONTINENT CONVERGENCE = SUBDUCTION

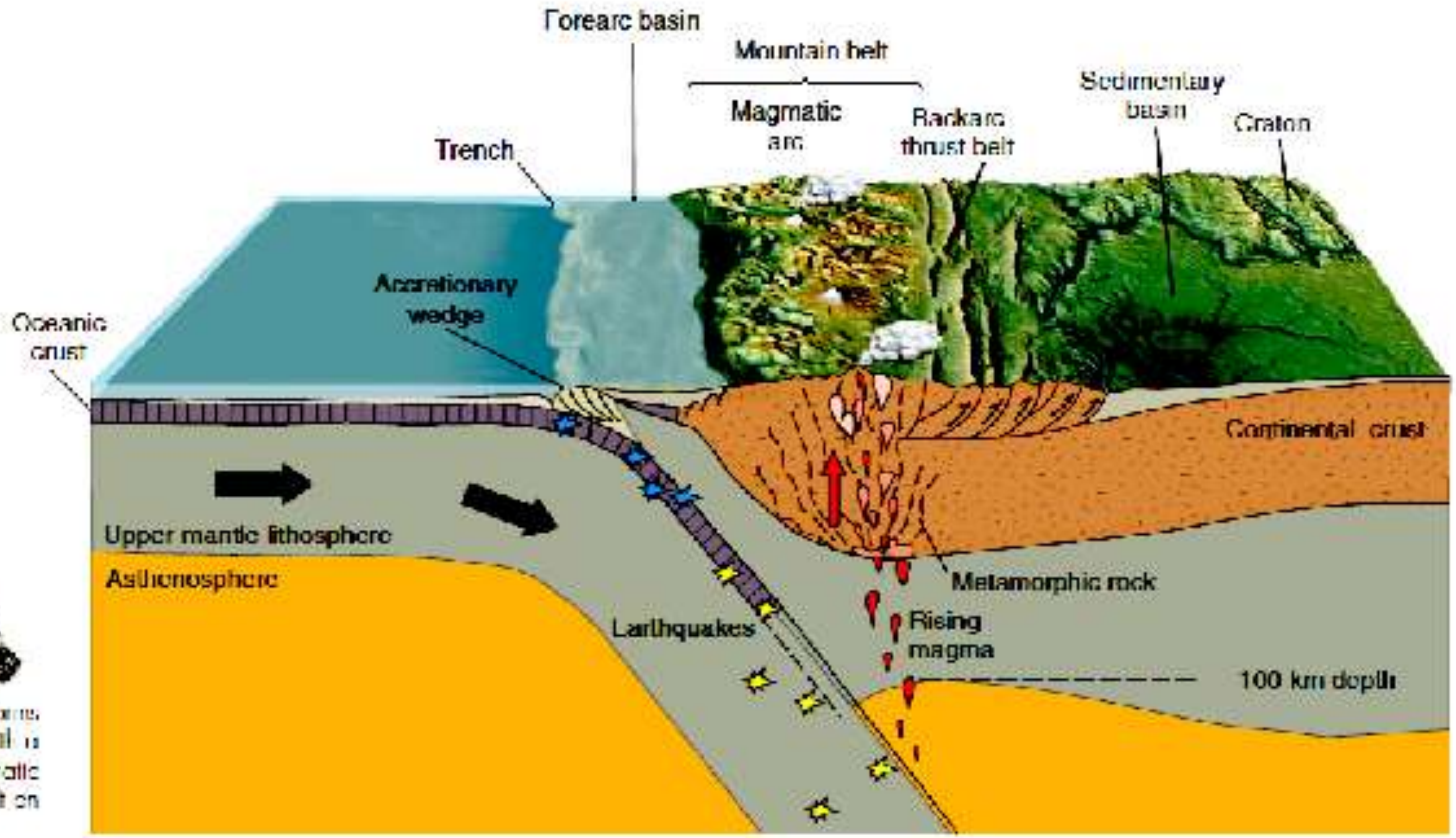
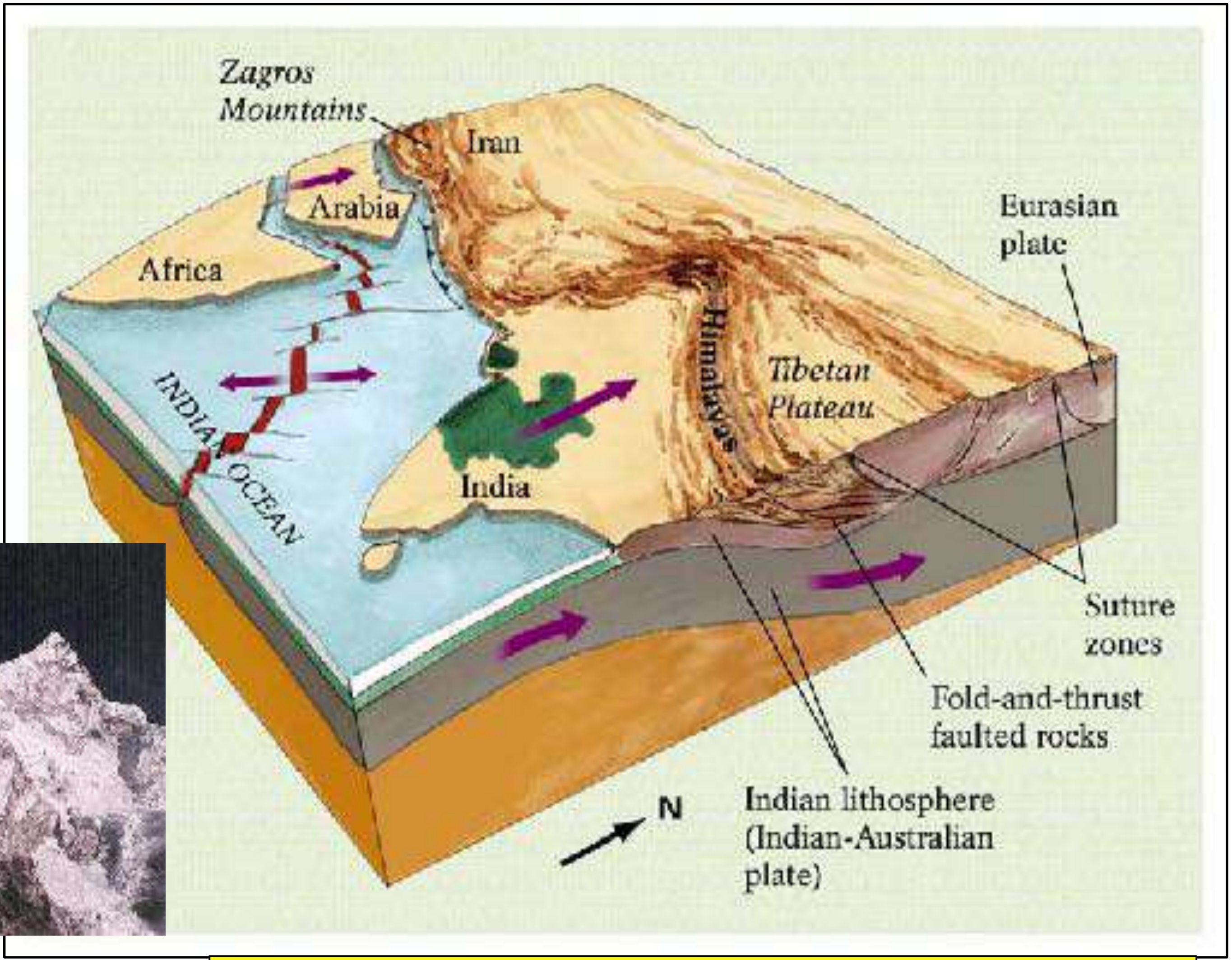


FIGURE 4.27

Ocean-continent convergence forms an active continental margin with a trench, a Benioff zone, a magmatic arc, and a young mountain belt on the edge of the continent.

Plate Tectonics

CONTINENT-CONTINENT CONVERGENCE = COLLISION



Results in the growth of Continental Crust

CONTINENT-CONTINENT CONVERGENCE = COLLISION

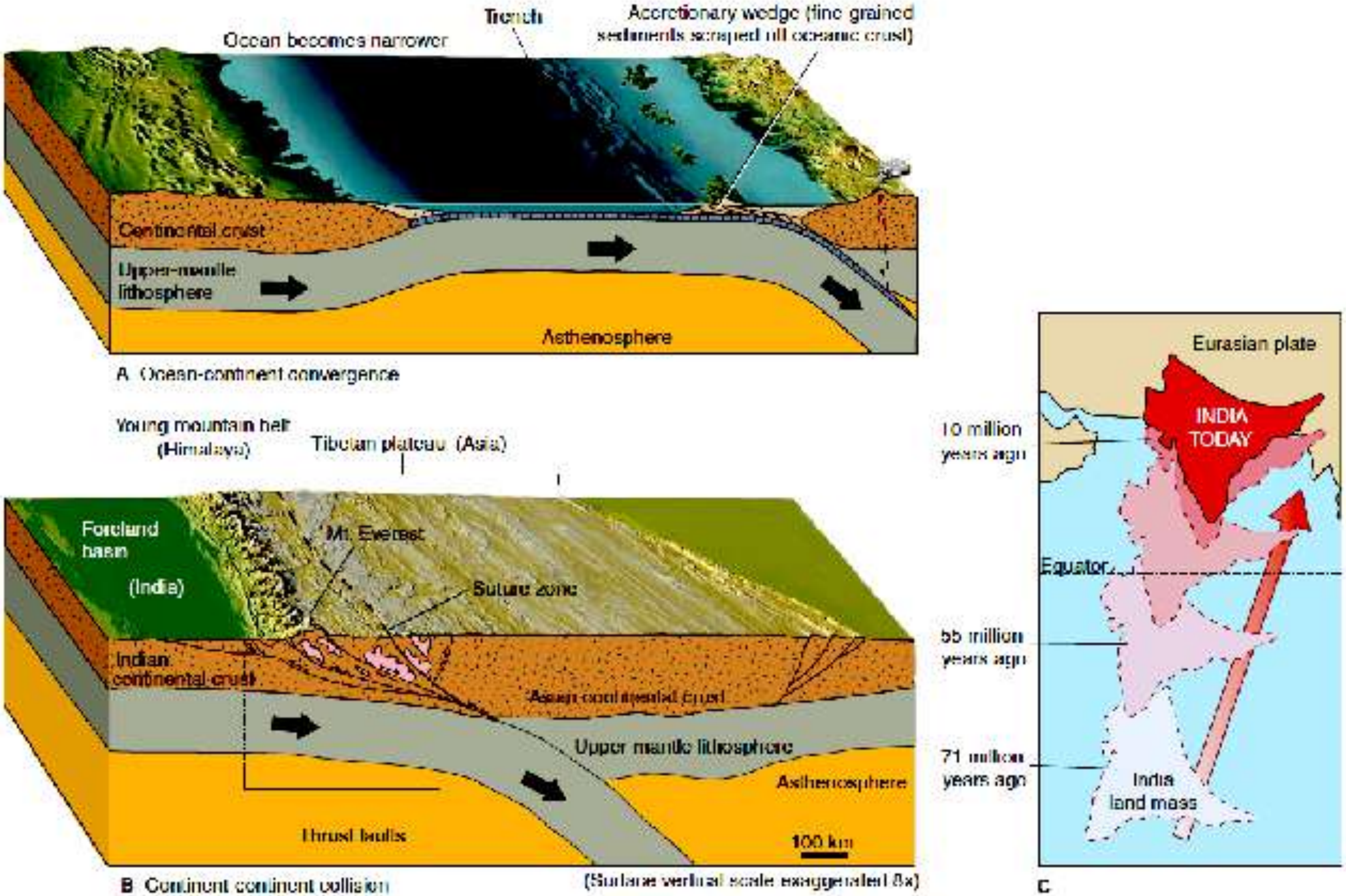


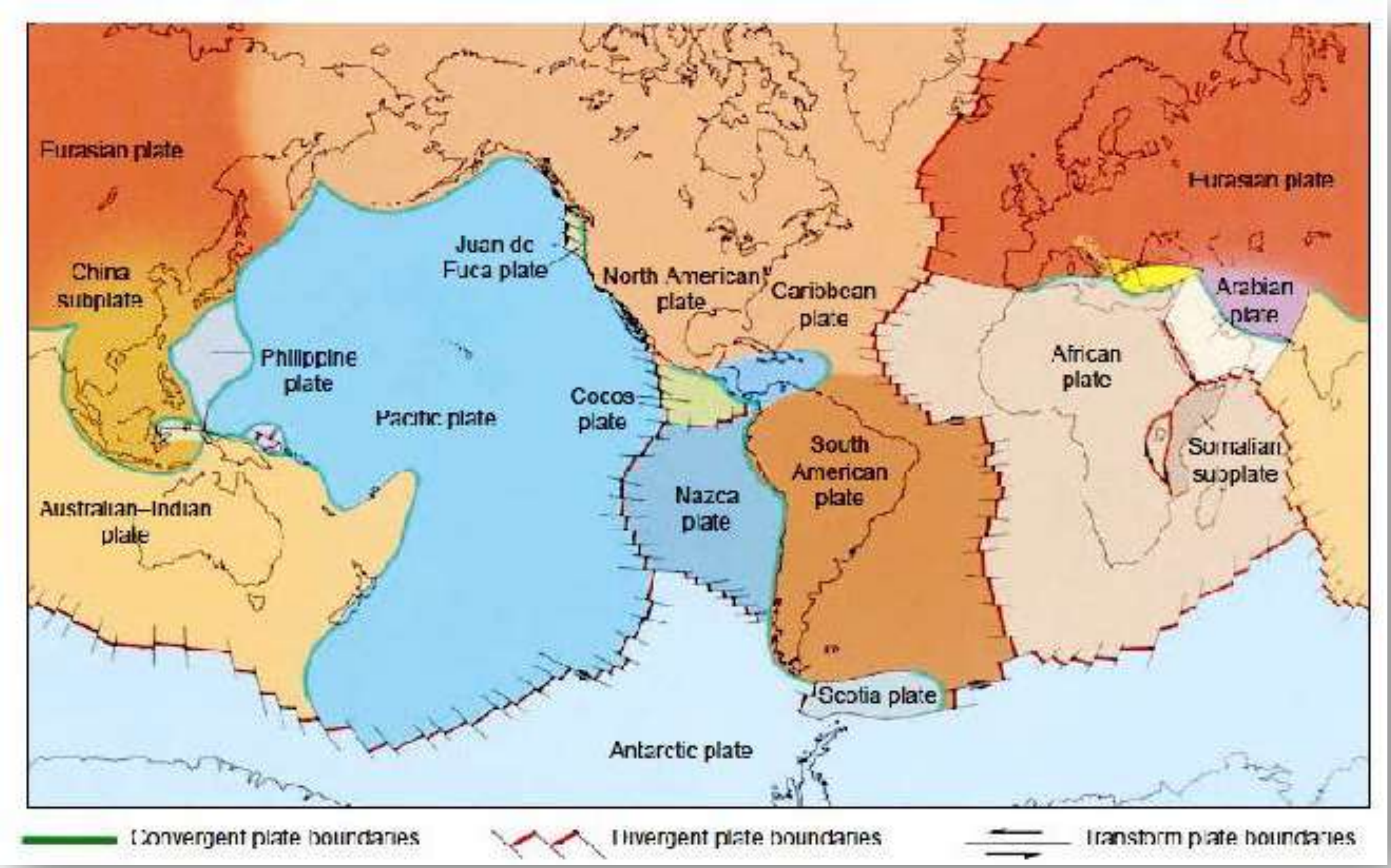
FIGURE 4.28

The collision of two continents forms a young mountain belt in the interior of a new, larger continent. The most famous example of continent-continent collision is the collision of India with Asia. (A) India is moving toward Asia due to ocean-continent convergence. (B) India collides with Asia to form the Himalayas, the highest mountain range on Earth. (C) Map view of the northward movement of India through time.

BASIC PLATE TECTONICS – Revised

- Earth's lithosphere is broken into 12-24 rigid plates
- Plates move about 1-10 cm/yr on the plastic Asthenosphere
- "Geology happens" where the plates interact with one another along Divergent, Transform, Subduction and Collisional Boundaries

Tectonic Plates of the Earth



(Hamblin & Christiansen, 2009)

Thank You