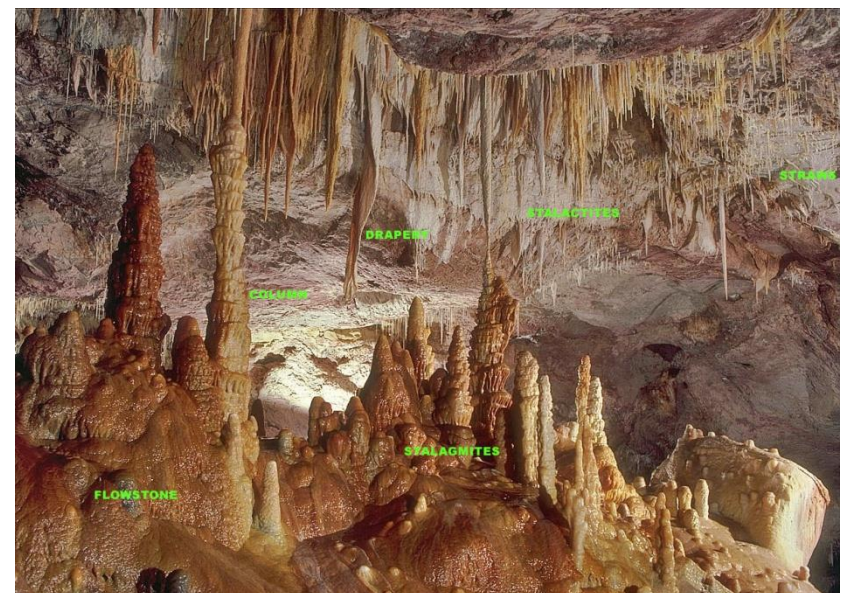




IDC 203: INTRODUCTION TO EARTH SCIENCES



Introduction

- 1. Continental Hypothesis**
- 2. Sea floor spreading**
- 3. Plate tectonics**

Plate tectonics

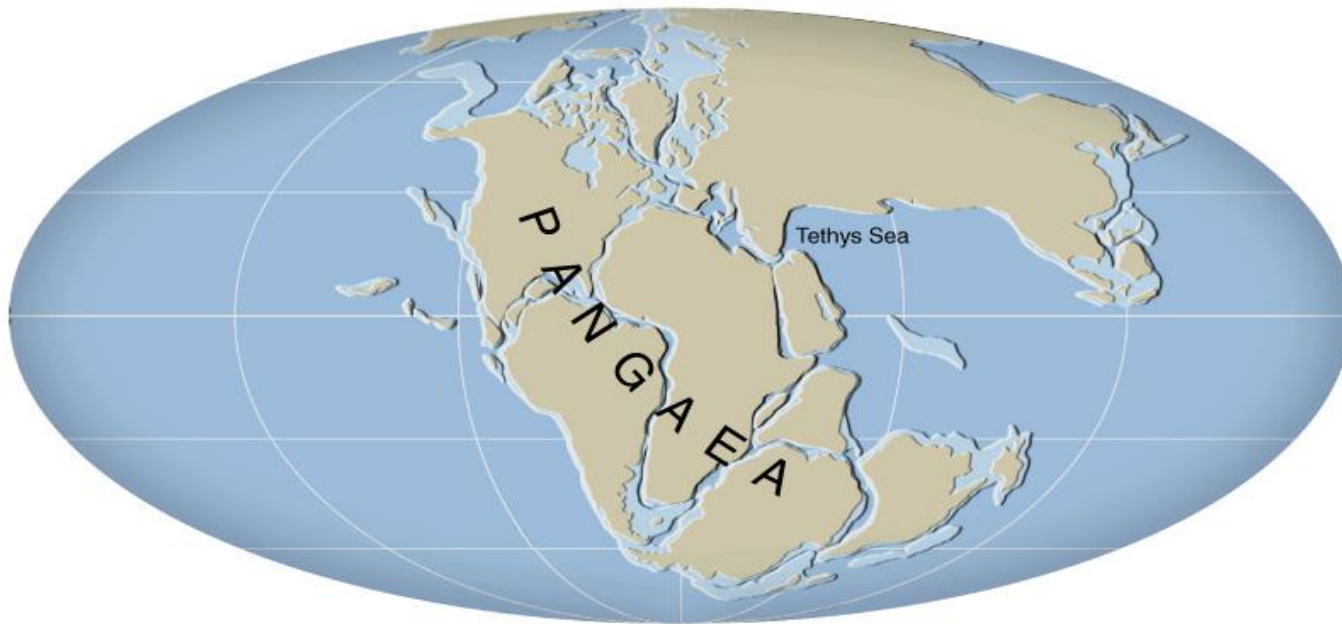
- Plate tectonics is the theory that explains the global distribution of geological phenomena.
- Refers to the movement and interaction of the earth's lithosphere.
- Plate tectonics describes the movement of plates and forces acting on them

Evidence of Continental drift

- Seuss, 1885, proposed 'Gondwanaland' by studying fossils, rocks, mountains
- Wegener and Taylor, early 1900's, proposed continental drift and Pangaea
- Evidence supporting the idea that the continents had drifted.
 - Geographic fit of continents
 - Fossils
 - Mountains
 - Glaciation

Evidence of Continental drift

Geographic fit



Continents seem to fit together like pieces of a puzzle

Evidence of Continental drift

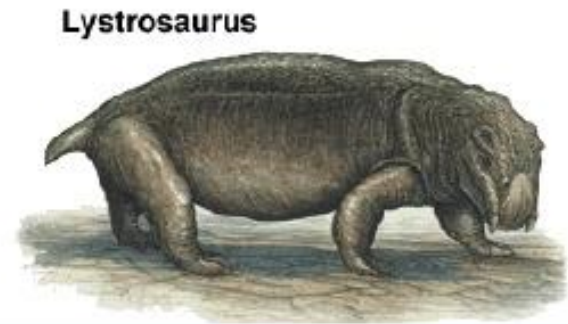
Fossils



Similar distribution of fossils such as the *Mesosaurus*

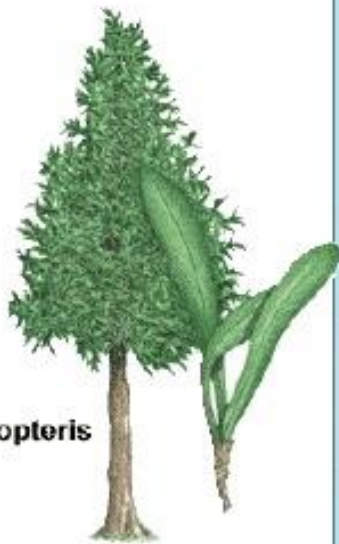
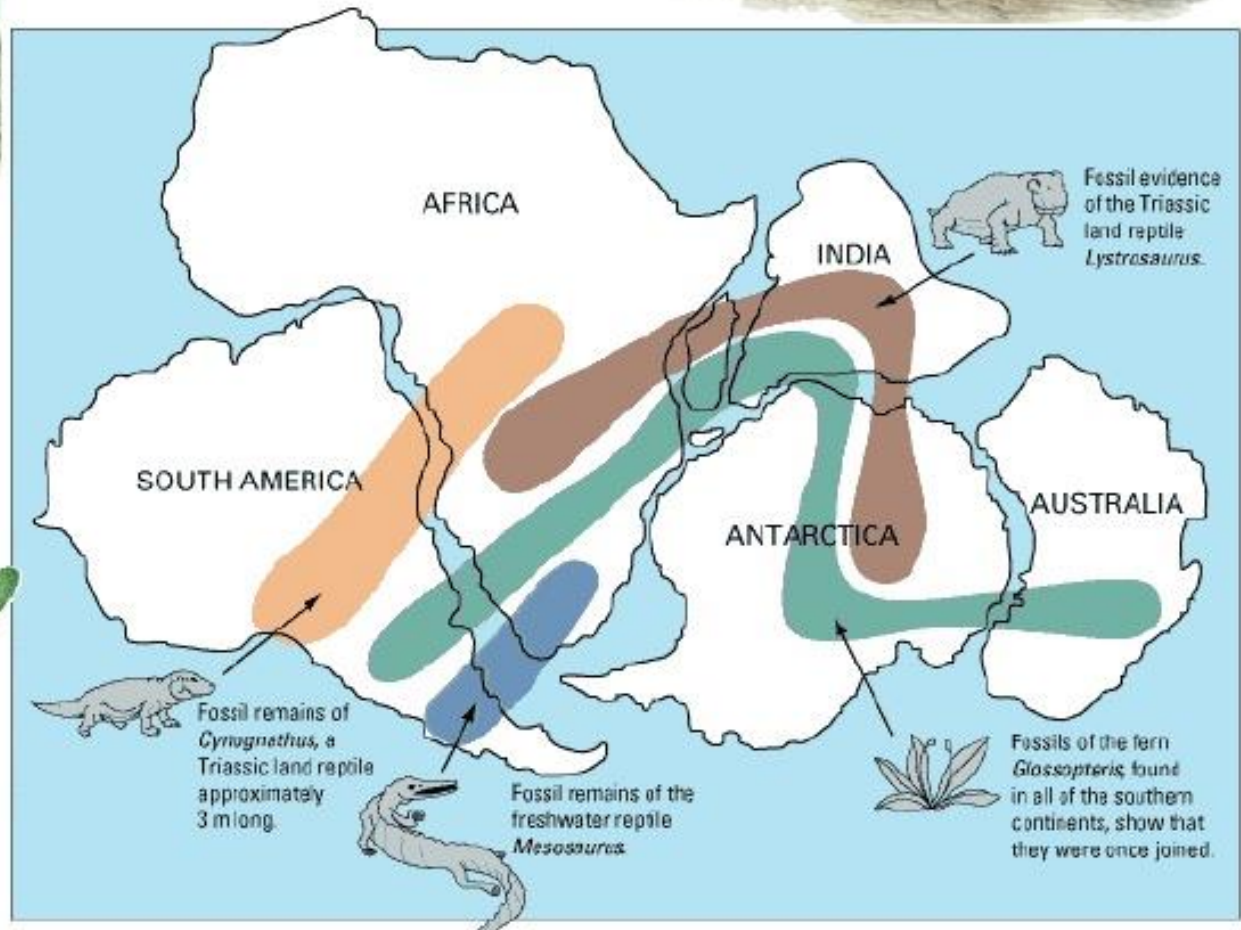


Mesosaurus



Lystrosaurus

Fossil Evidence for Continental Drift



Glossopteris

Glossopteris



Evidence of Continental drift

Mountain chain



A.

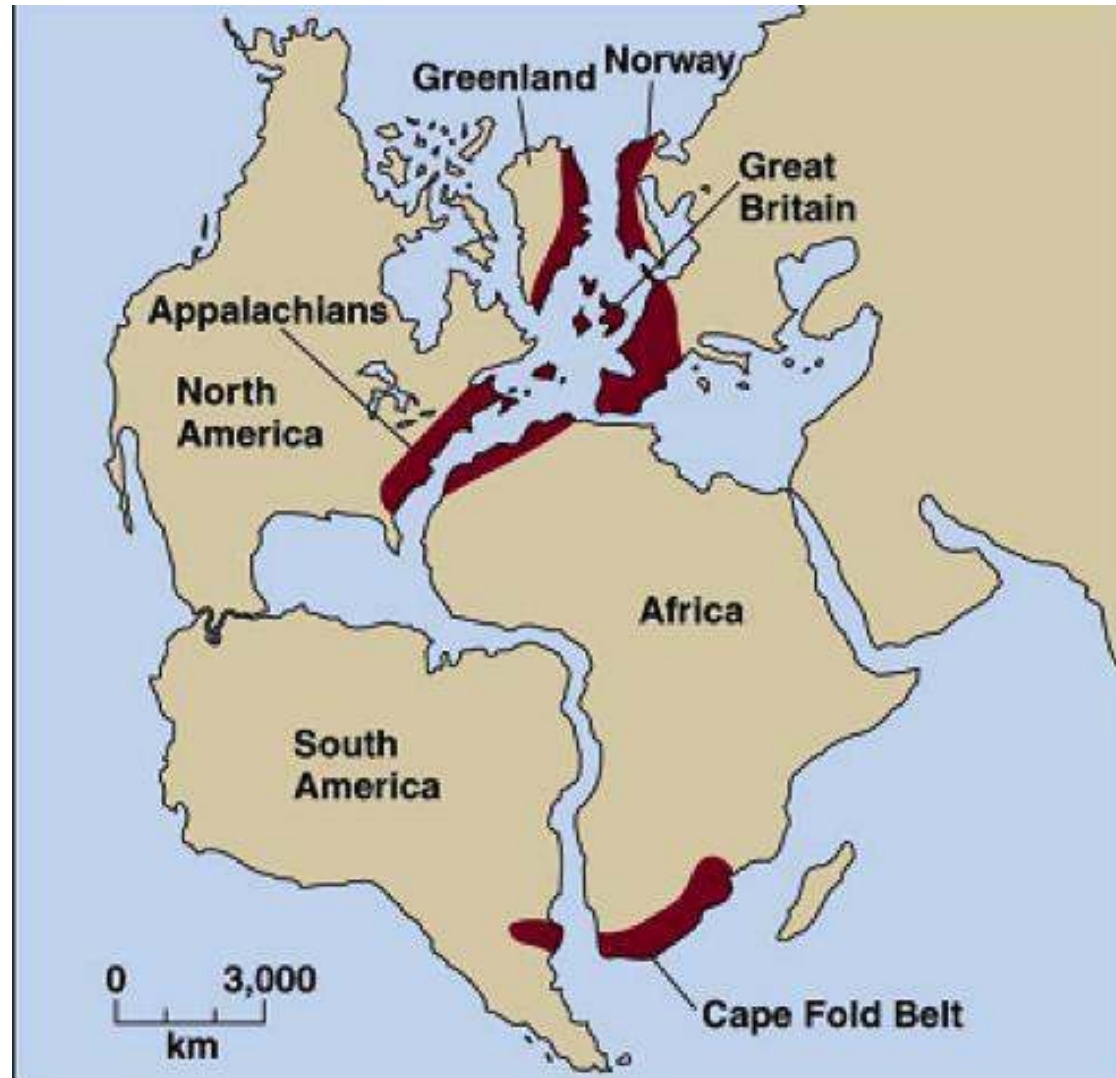


B.

Mountain ranges match across oceans

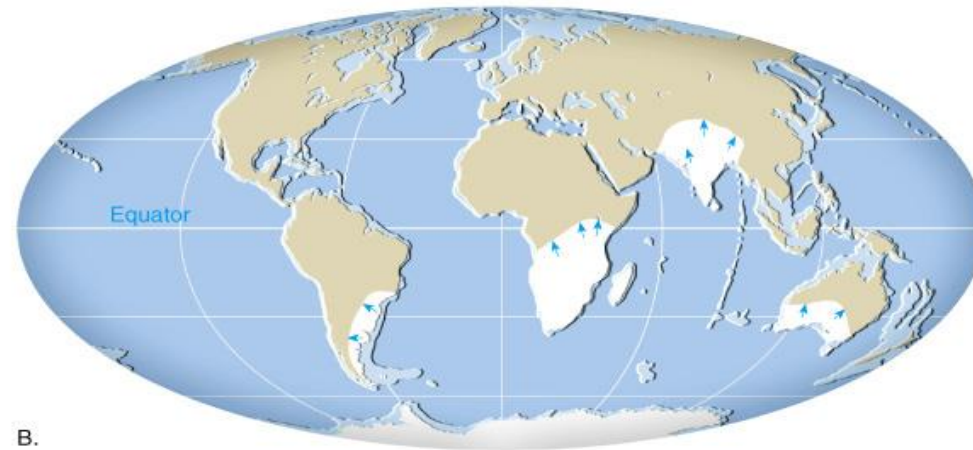
Evidence of Continental drift

Rock types



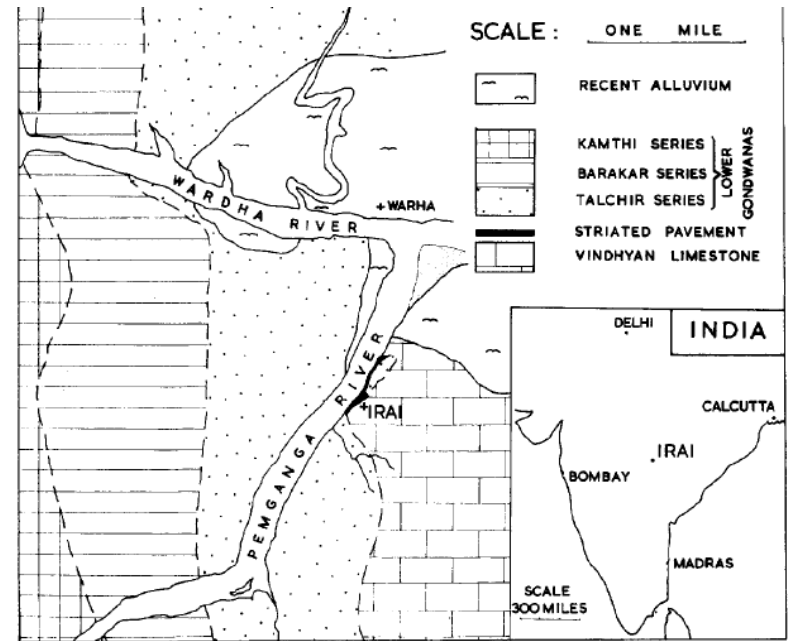
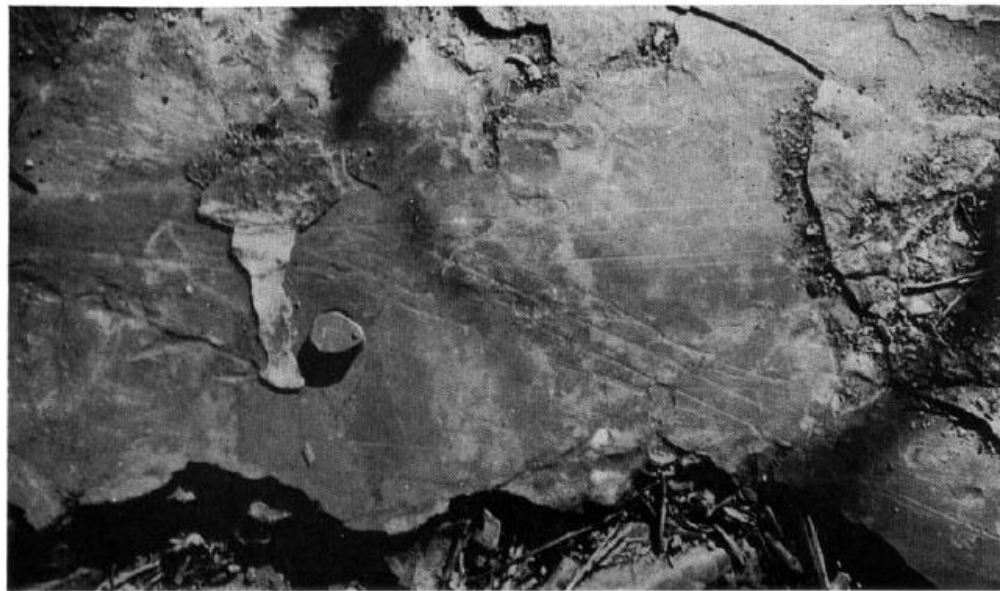
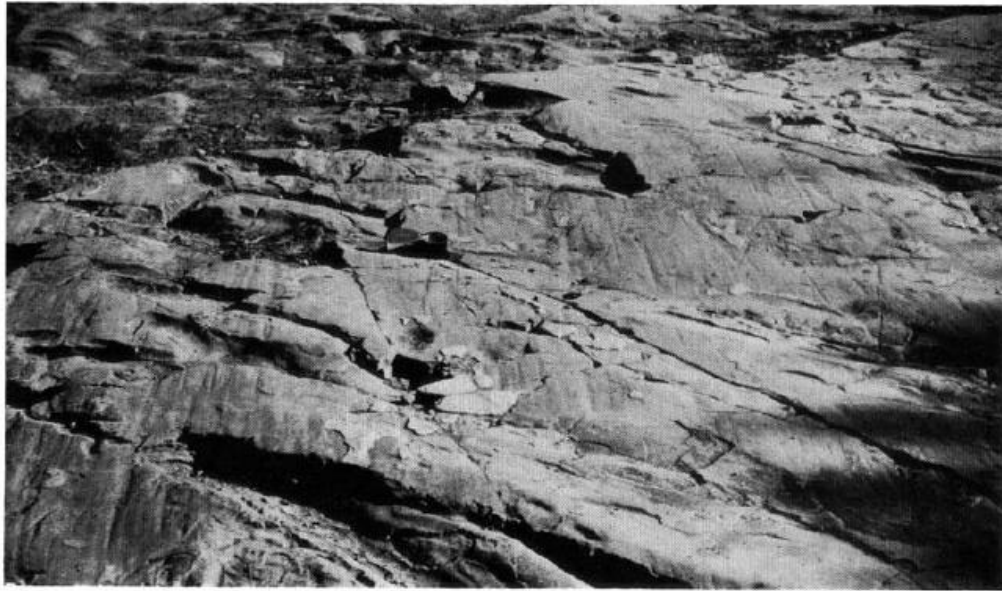
Evidence of Continental drift

Glaciers



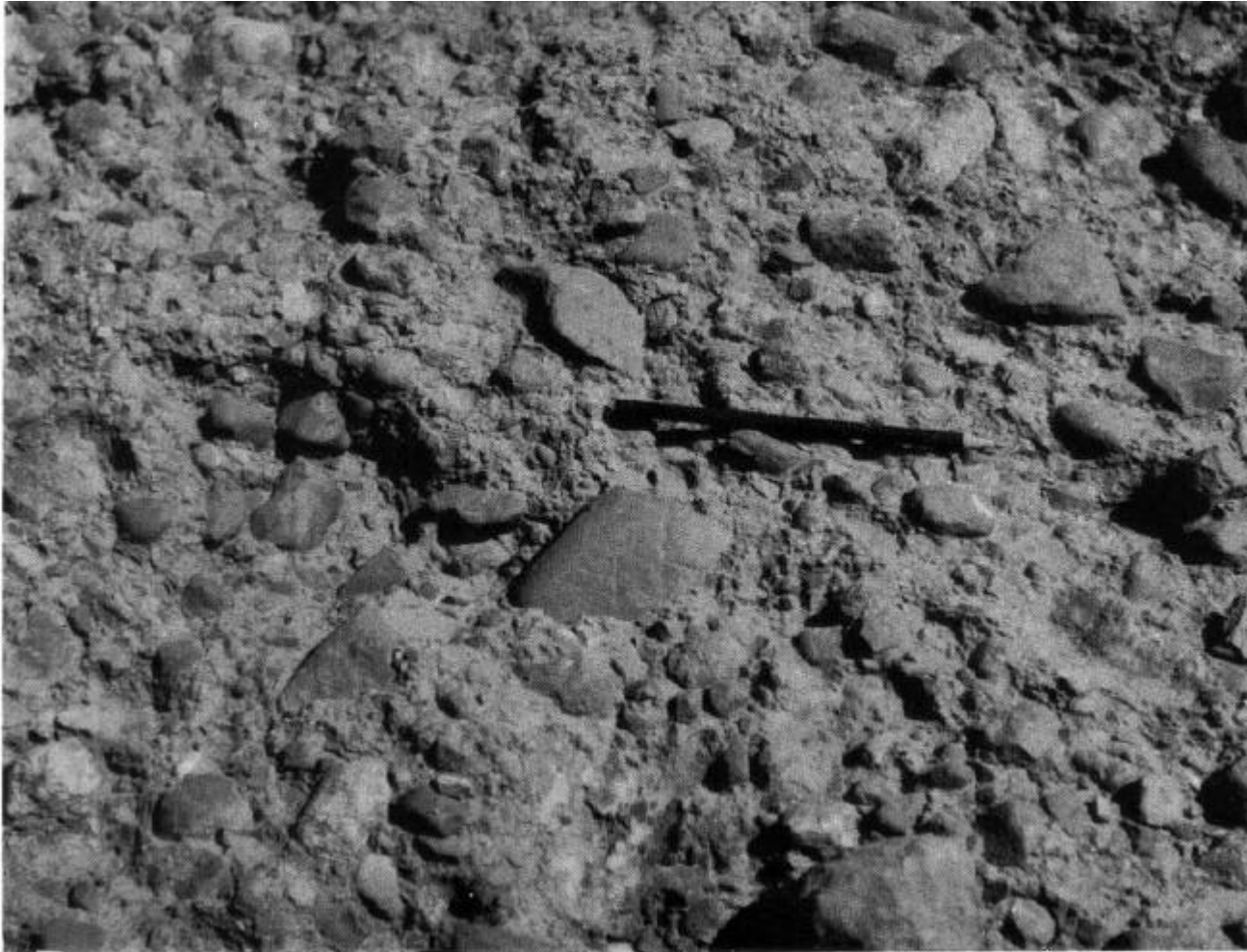
Glacial ages and climate evidence

**EVIDENCE FOR A TALCHIR (LOWER GONDWANA) GLACIATION:
STRIATED PAVEMENT AND BOULDER BED
AT IRAI, CENTRAL INDIA¹**



Source: Smith, 1963

**EVIDENCE FOR A TALCHIR (LOWER GONDWANA) GLACIATION:
STRIATED PAVEMENT AND BOULDER BED
AT IRAI, CENTRAL INDIA¹**



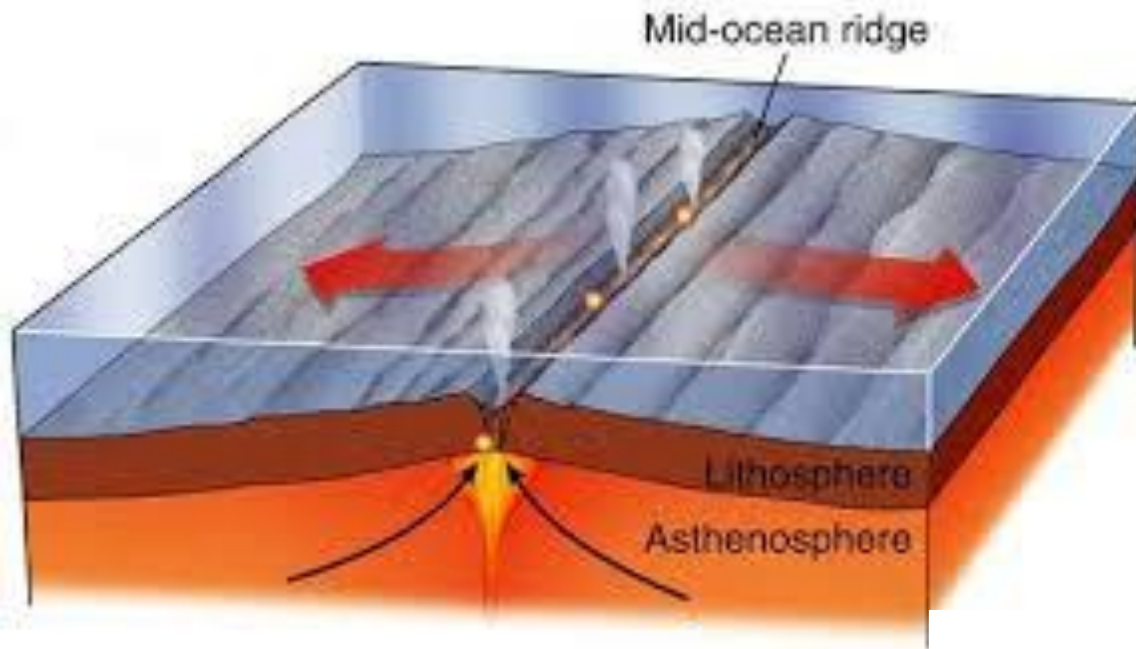
Rejection and acceptance of Continental drift

- Rejected by most geologists.
- Absence of mechanism involving movements of continents
- New data after WWII led to the “plate tectonic revolution” in 1960’s.
- Now embraced by essentially everybody.
- Today’s geology textbooks radically different than those of 40 years ago.

Seafloor spreading

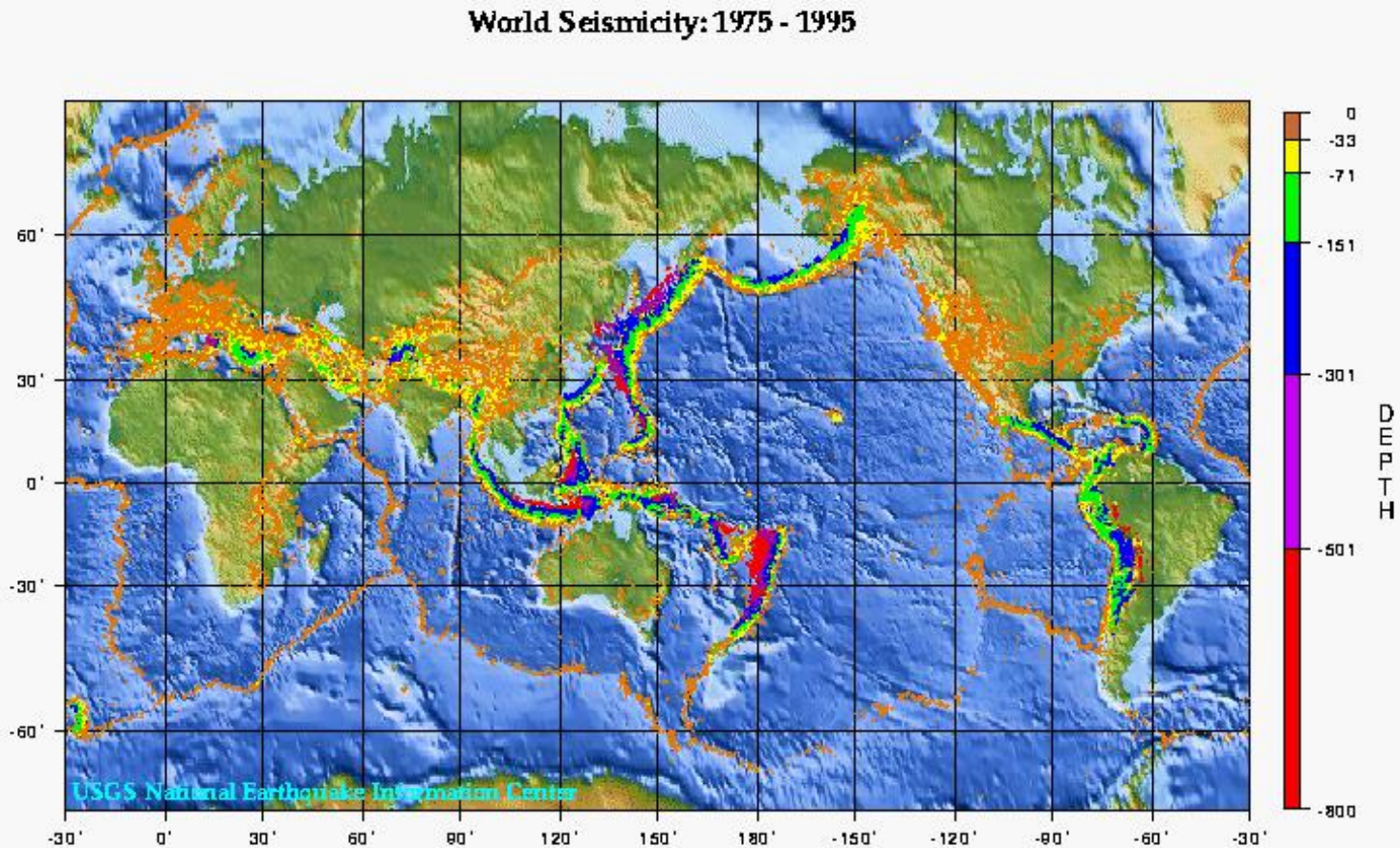
- Continental drift reexamined in 1960's with new information
- Supporting evidence for seafloor spreading
 - World seismicity
 - Volcanism
 - Age of seafloor
 - Paleomagnetism
 - Heat flow

Mid oceanic ridge



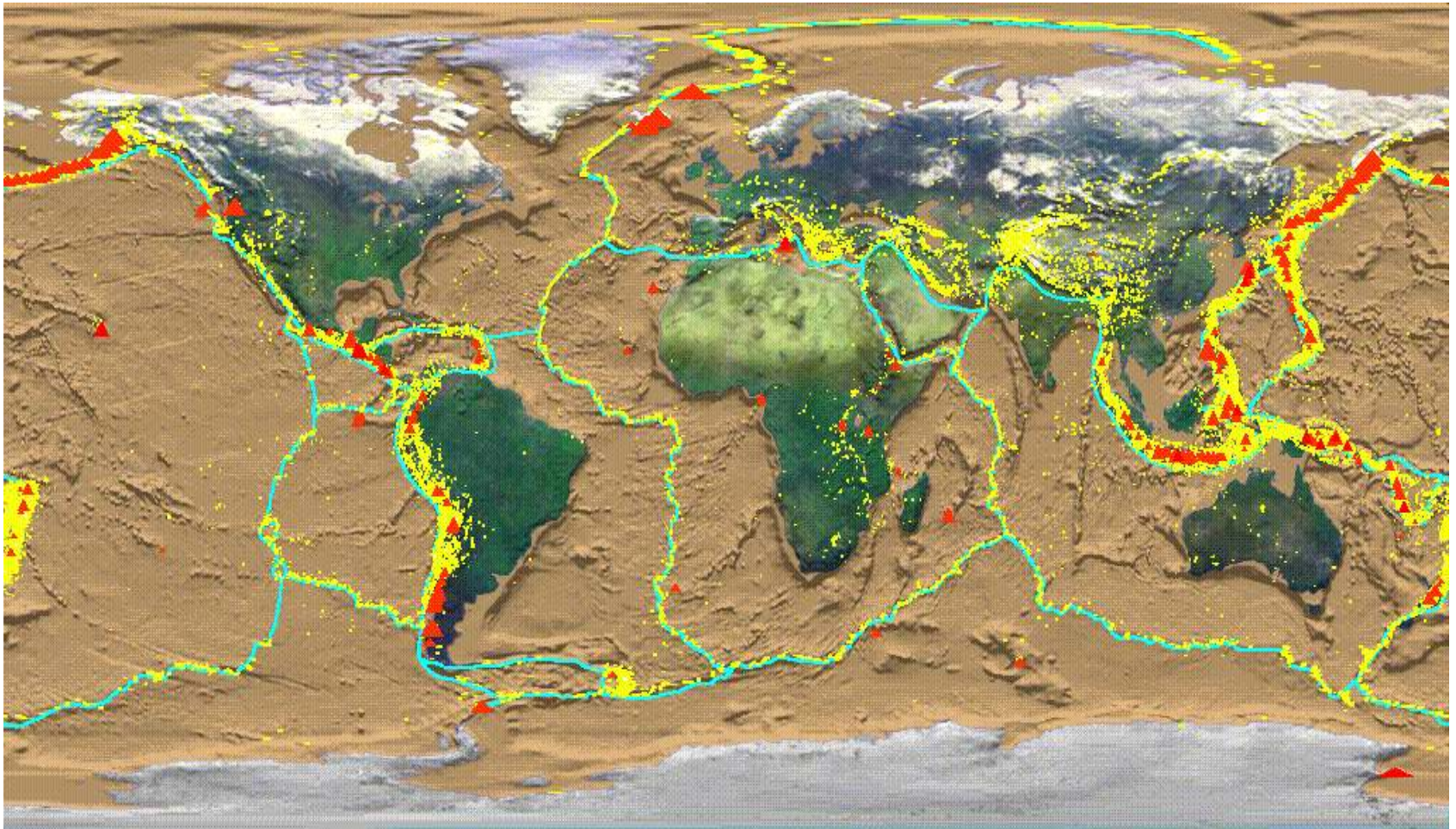
Evidence of sea floor spreading

Seismicity



Evidence of sea floor spreading

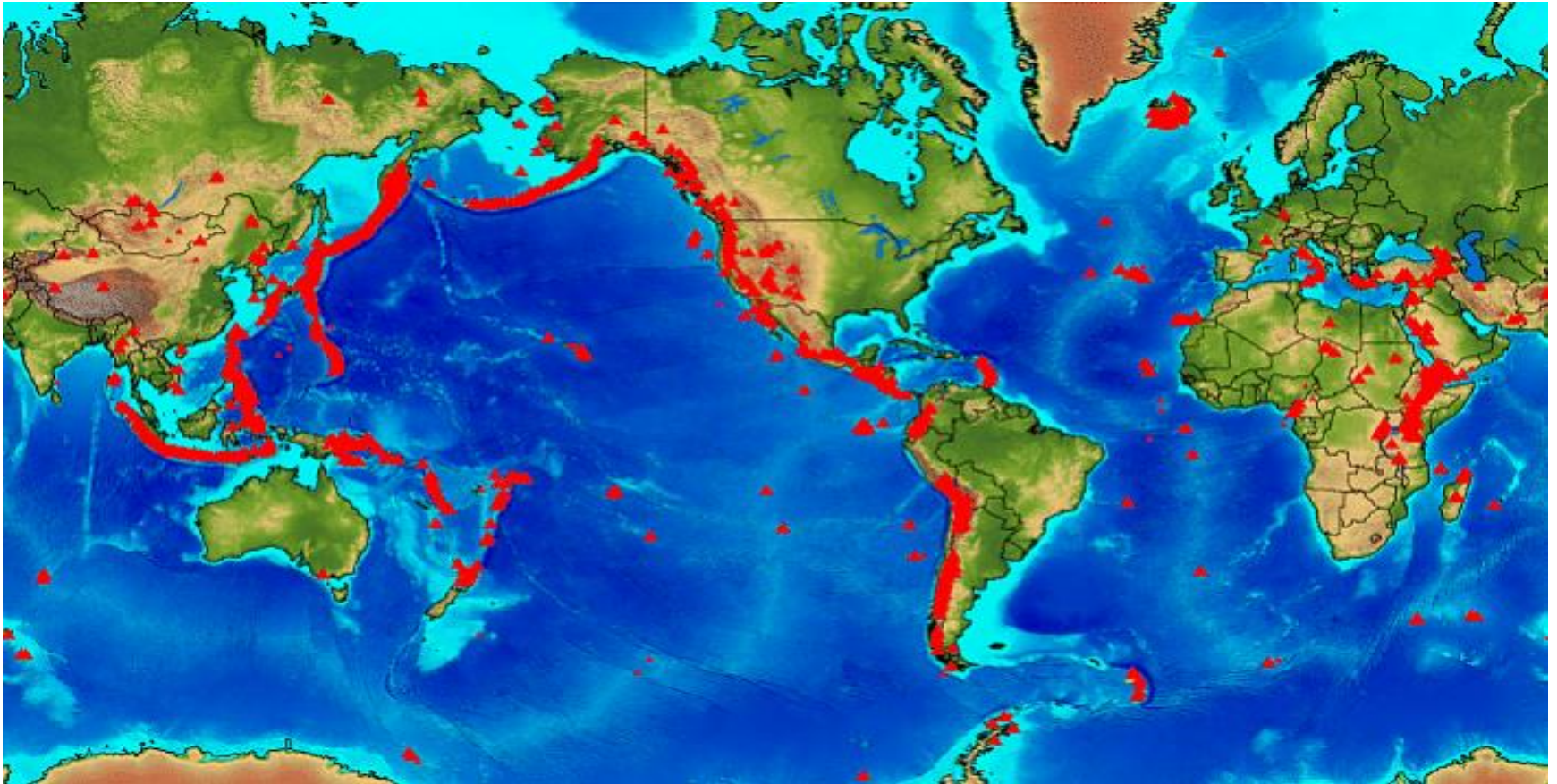
Seismicity



Earthquake distribution matches plate boundaries

Evidence of sea floor spreading

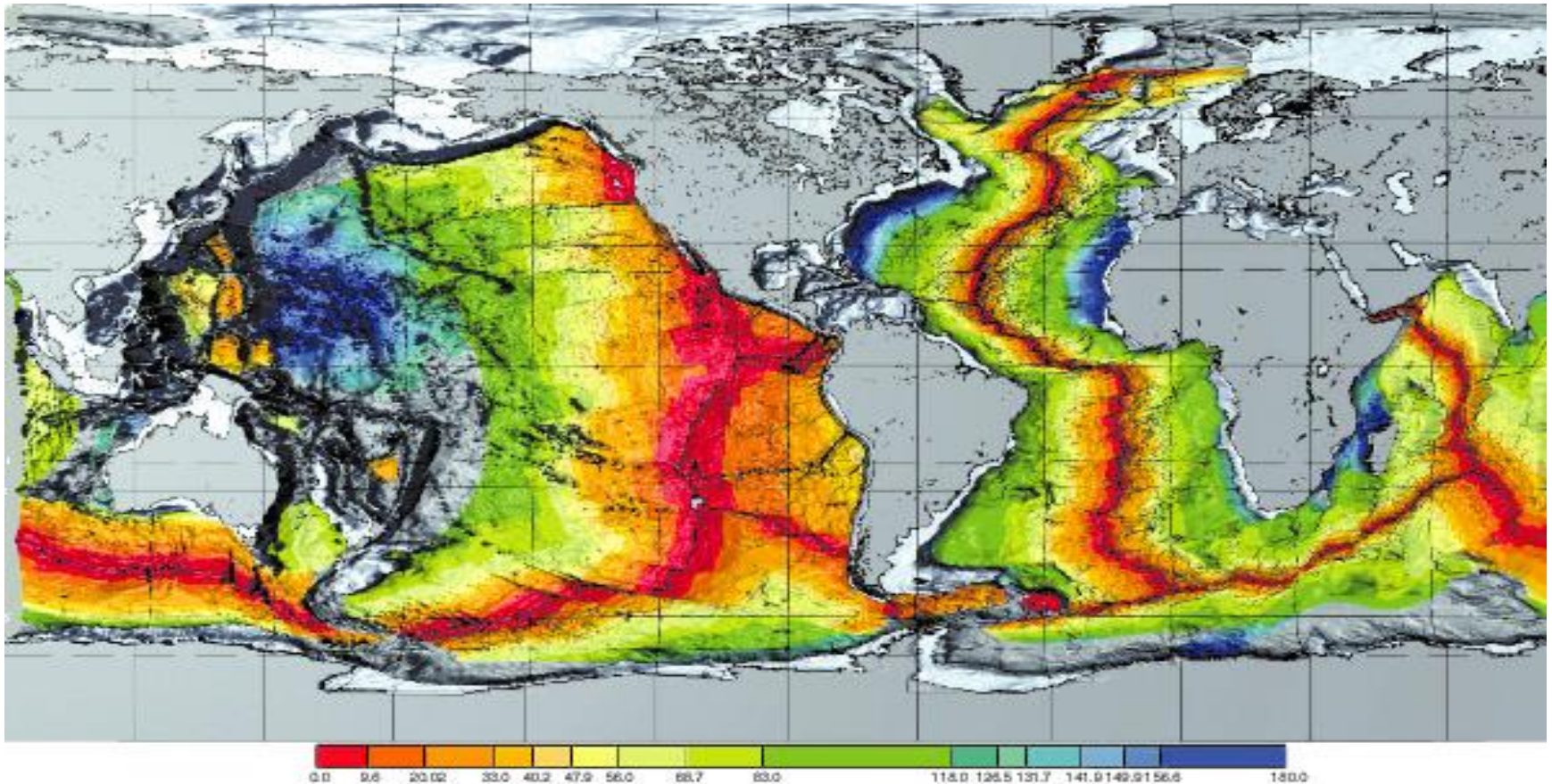
Volcanism



Volcanoes match some plate boundaries

Evidence of sea floor spreading

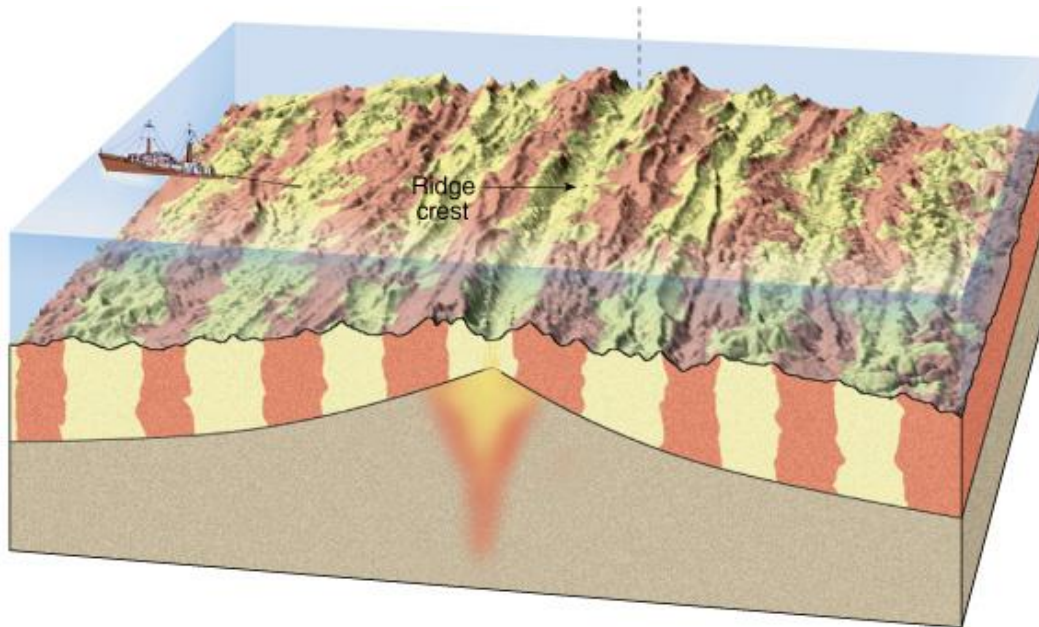
Age of the oceanic crust



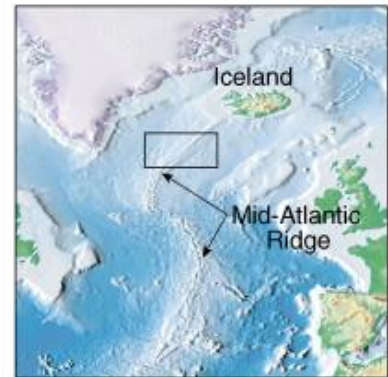
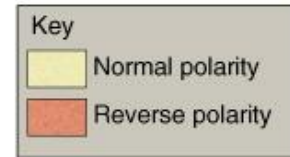
- Youngest sea floor is at mid-ocean ridge
- Oldest sea floor away from mid-ocean ridge

Seafloor spreading

Paleomagnetism



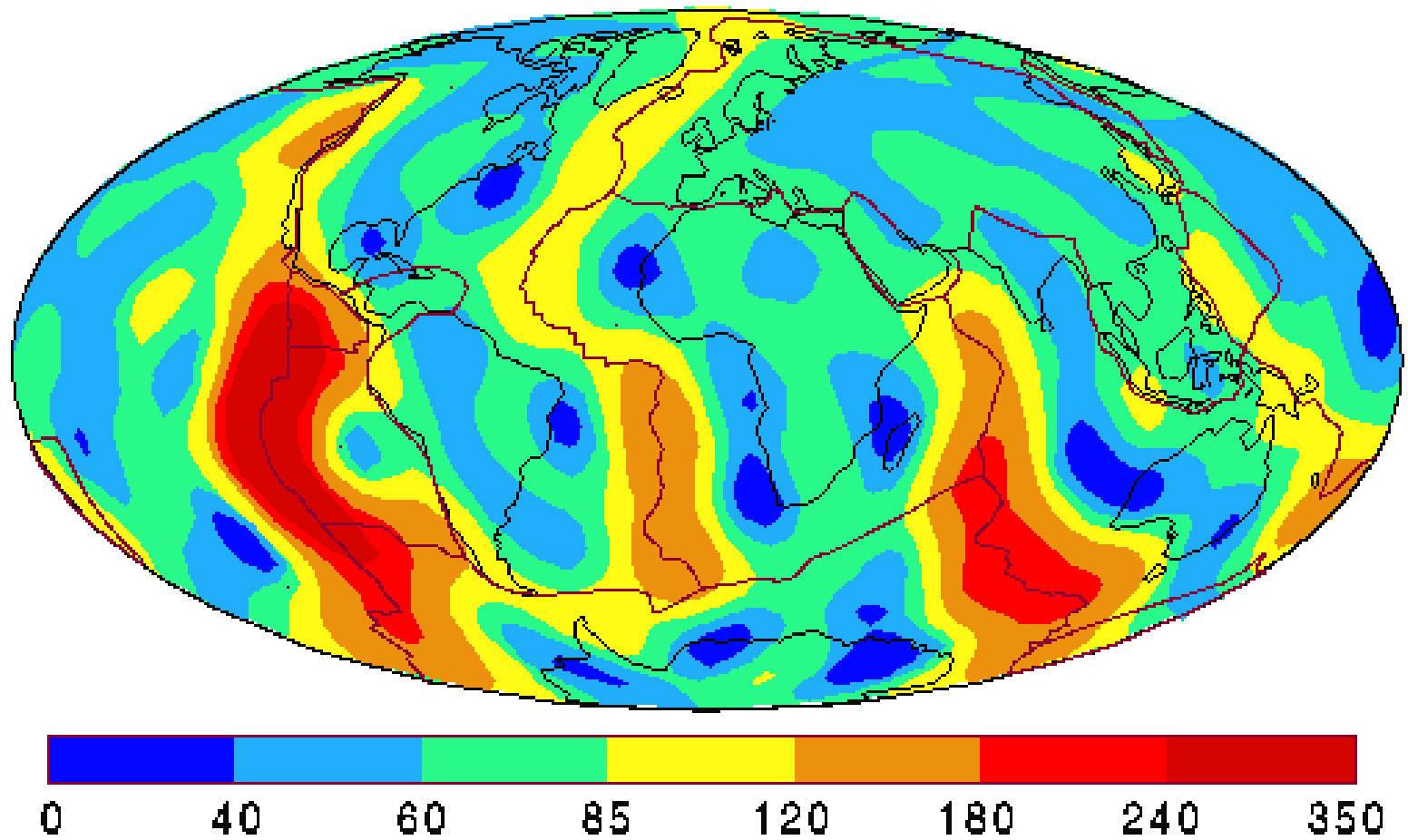
B. Research vessel towing magnetometer across ridge crest



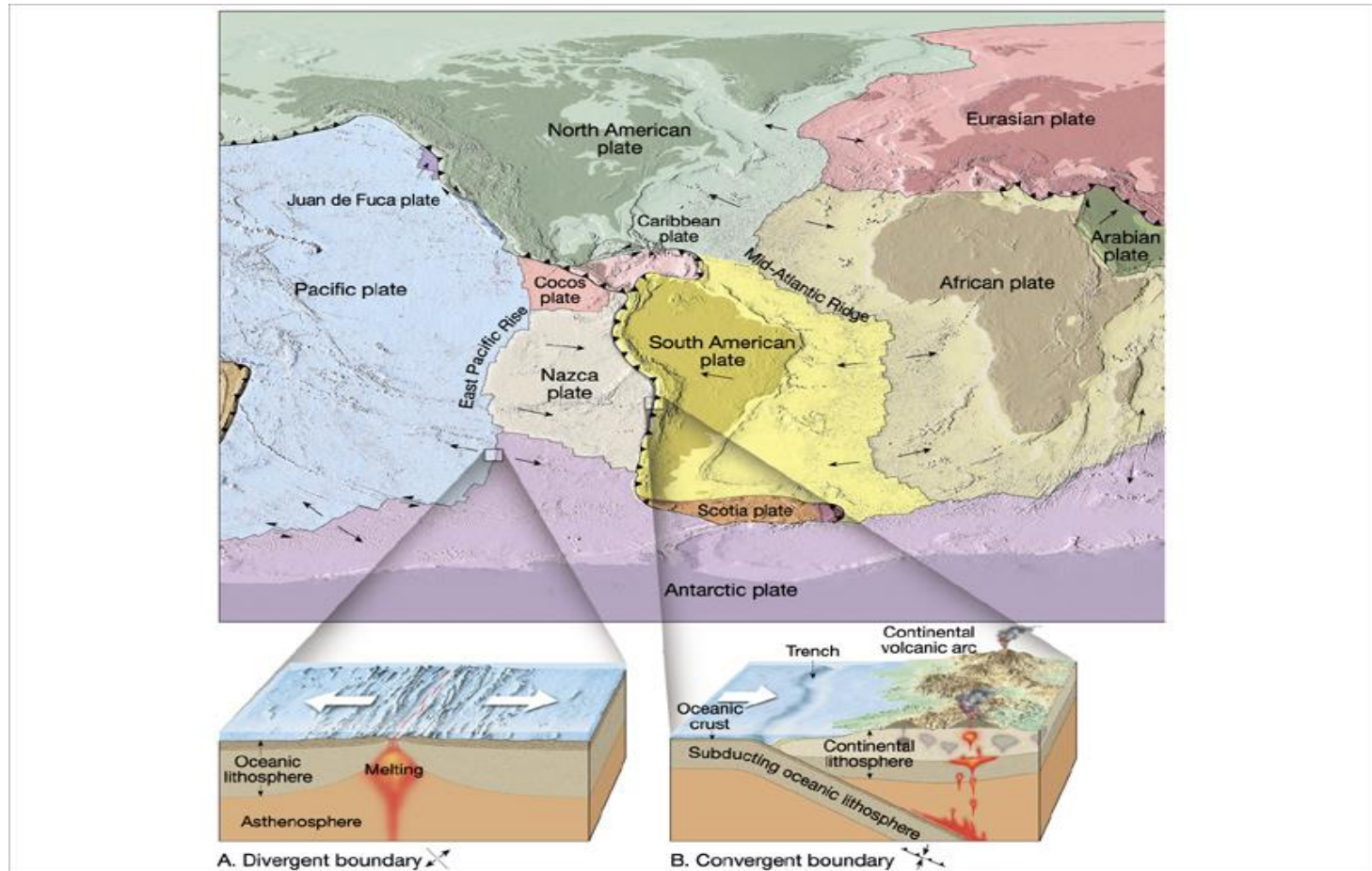
C. Location map

Seafloor spreading

Heat flow



Seafloor spreading



New sea floor created at the mid-ocean ridge and destroyed in deep ocean trenches

Plate tectonics

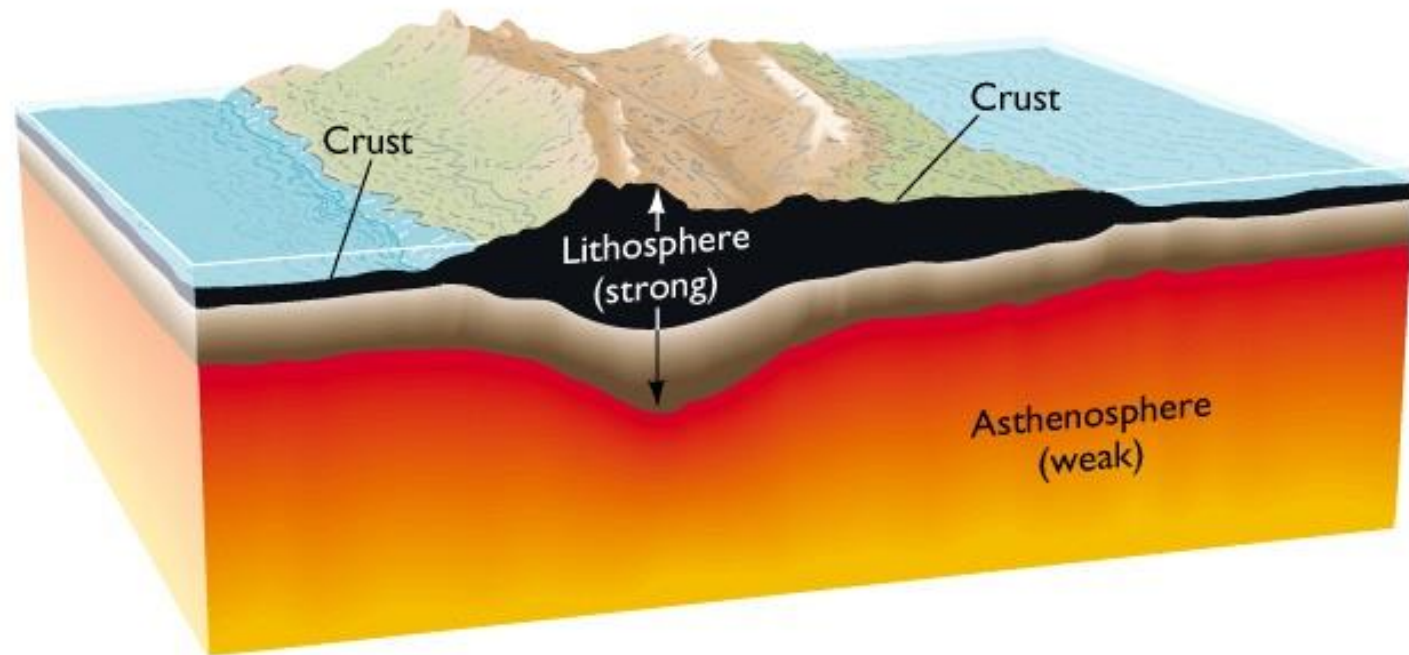
- The unifying concept of the Earth sciences.
- The outer portion of the Earth is made up of about 20 distinct “plates” (~ 100 km thick) that move relative to each other.
- Plates interact with each other along their edges (plate boundaries)
- Plate boundaries have high degree of tectonic activity
 - mountain building
 - earthquakes
 - volcanoes

Plate tectonics

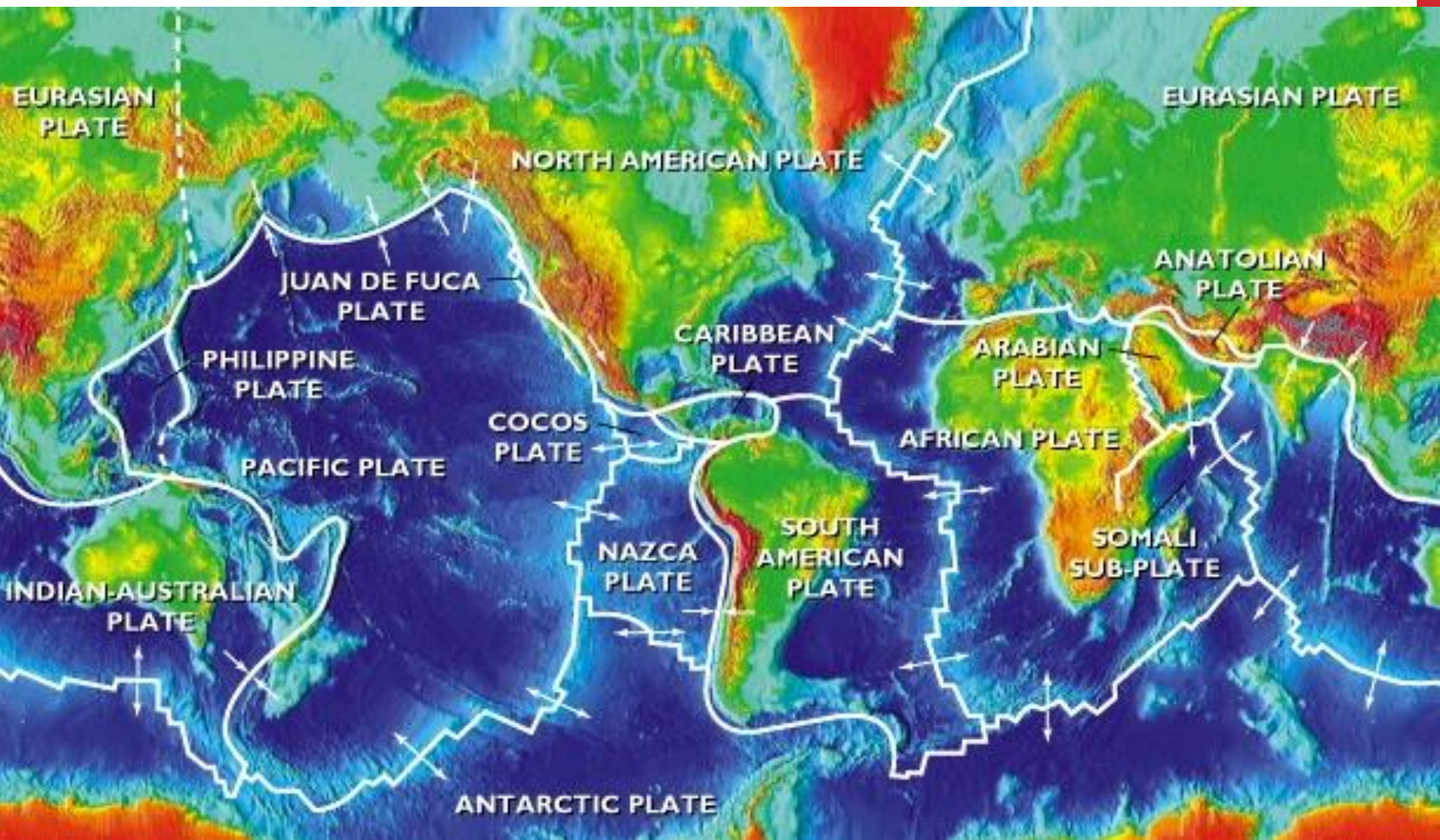
Lithosphere: the outer rigid shell of the earth (~ 100 km). The plates are composed of this material.

Asthenosphere: part of mantle beneath lithosphere.

The lithosphere rides on the top of the Asthenosphere



Present day plates



Three types of plate boundaries

1. Divergent
2. Convergent
3. Transform/Conservative

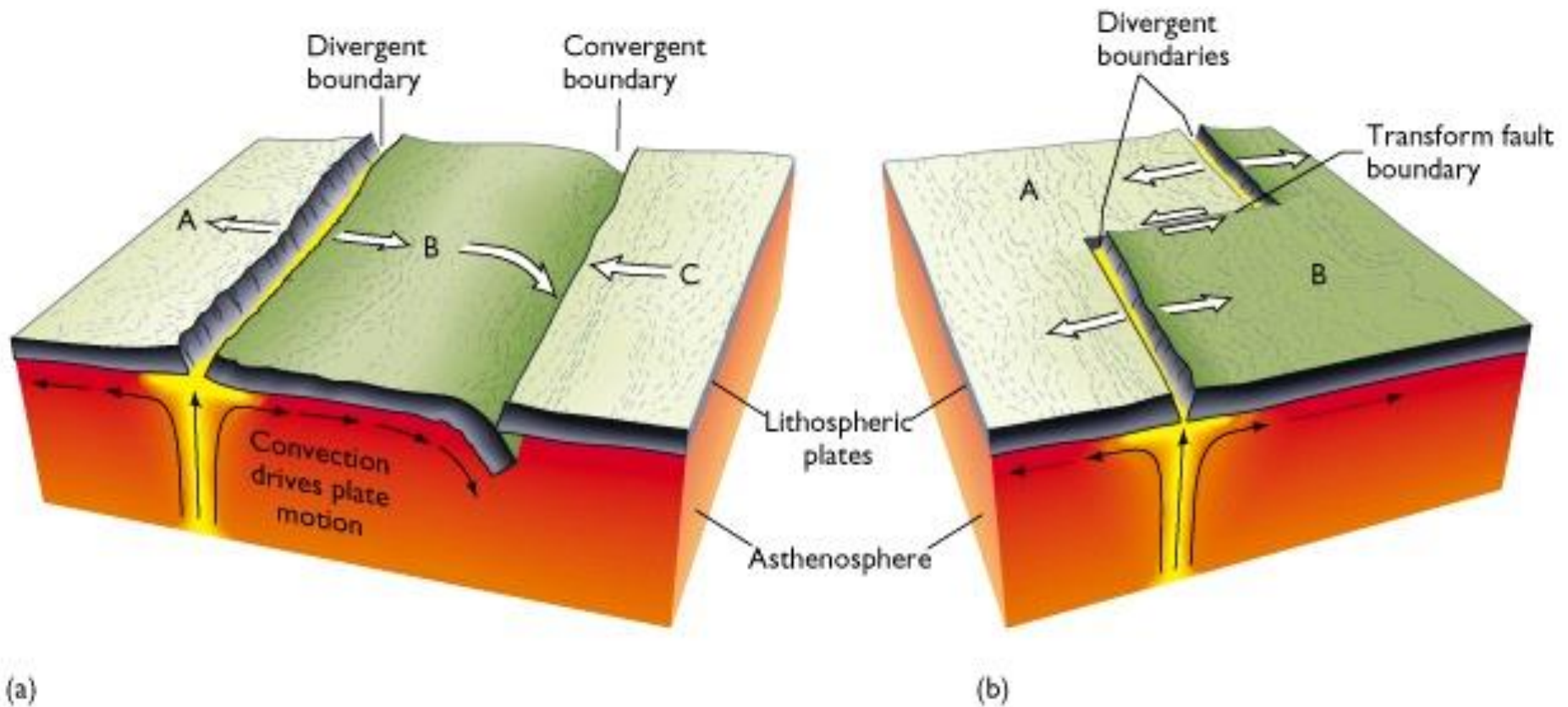
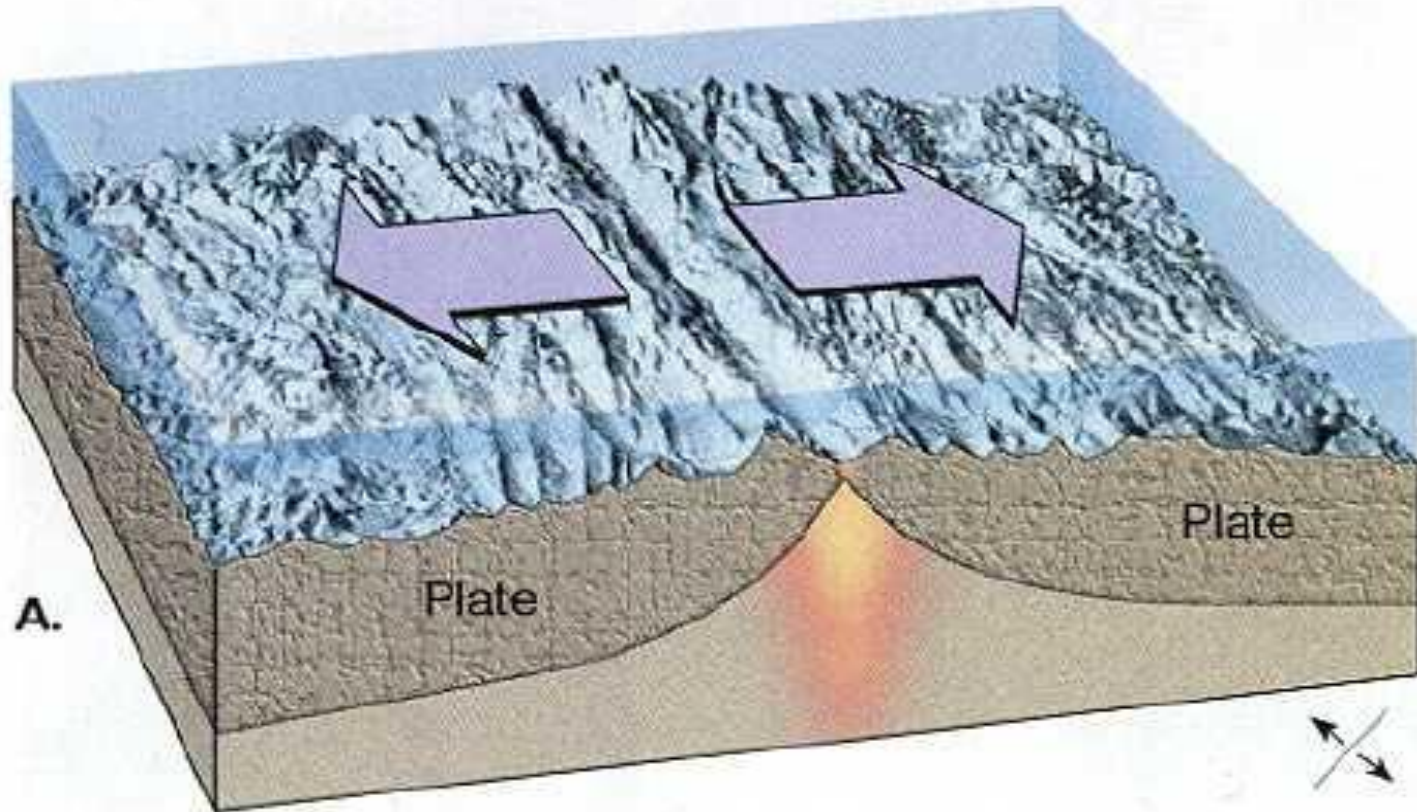


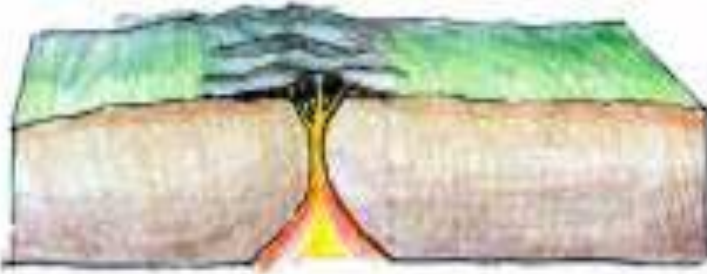
Plate Boundaries

Divergent



Plates move away from each other
New crust is being formed

Divergent Boundaries



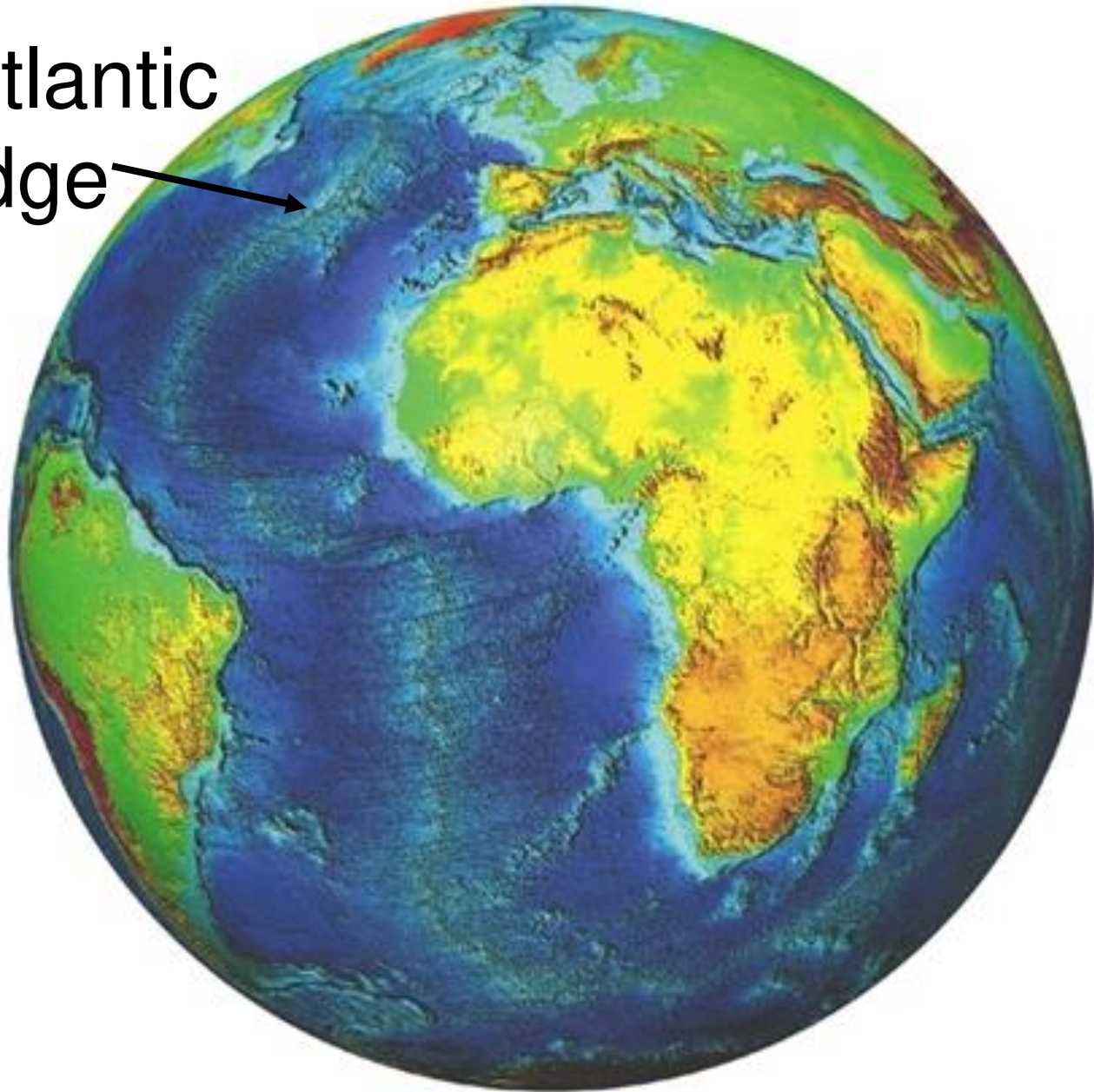
- Youngest rocks form at ridge



- Older rocks are further from ridge



Mid-Atlantic
Ridge

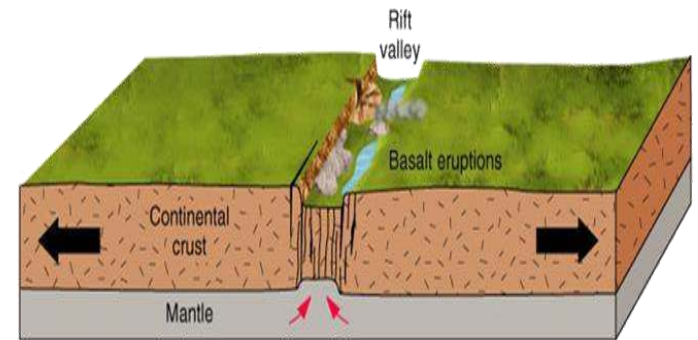


Divergent Boundaries

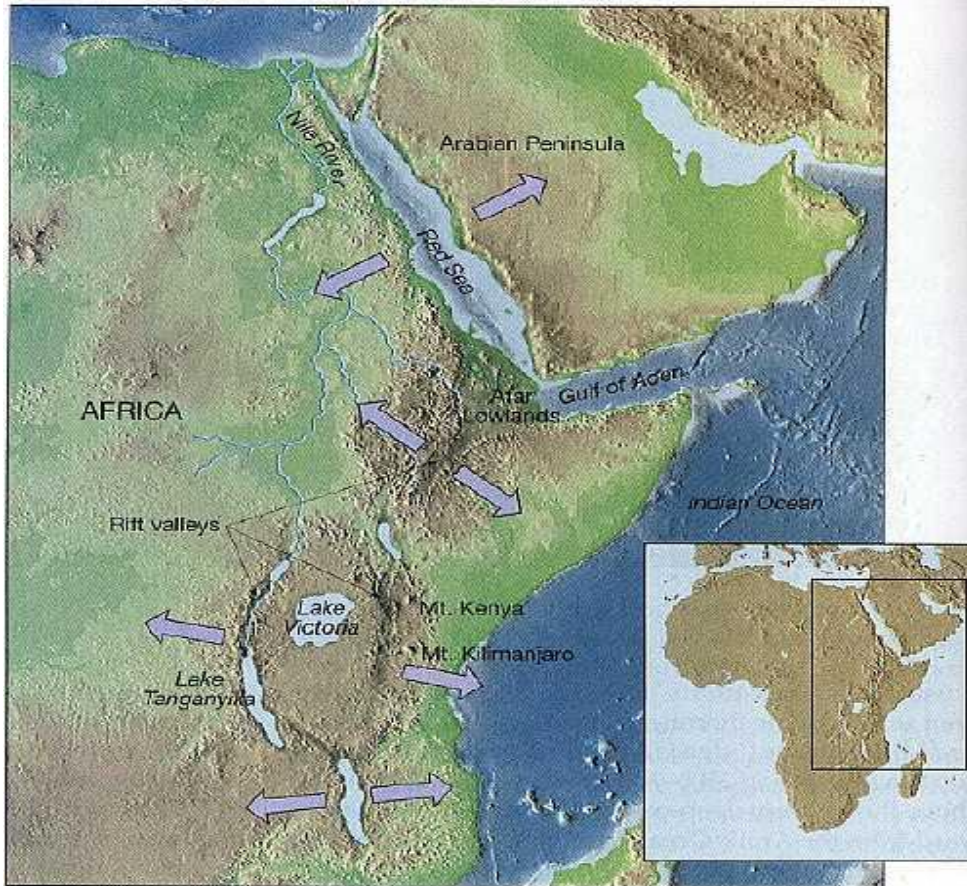


Europe and North America meet near Thingvellir, Iceland, where their two tectonic plates are slowly drifting apart. To the left is the far eastern edge of the North American continental plate, and to the right is the western edge of the Eurasian plate.

Rift valley
continent-continent



Divergent Boundaries



East African Rift



Mid-Atlantic Ocean Ridge



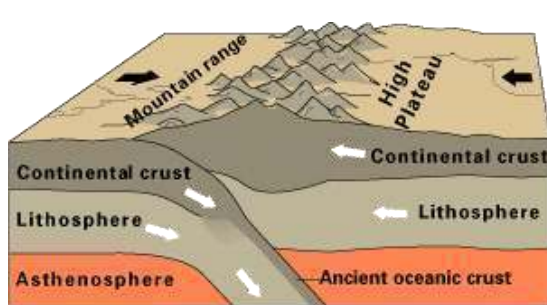
**ICELAND IS BEING
PULLED APART AS IT SITS
ASTRIDE THE MID-
ATLANTIC RIDGE.**

Convergent Boundaries

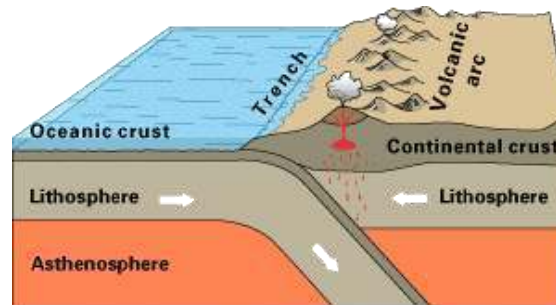
- Plates are moving toward each other
- Crust is being destroyed
- Three Types:
 - Ocean-continent
 - Ocean-ocean
 - Continent-continent

Convergent Boundaries

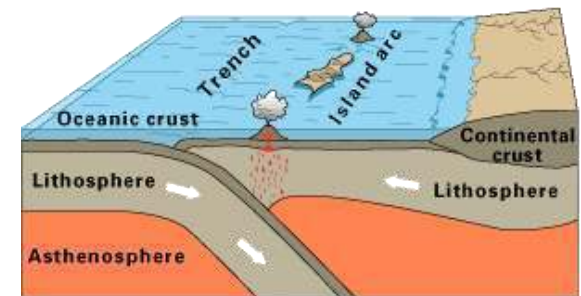
- Destroys old crust and forms new mountains
- Three types of convergent boundaries



Continental-continental convergence



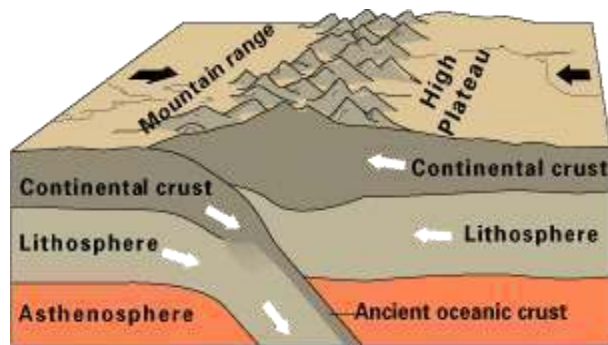
Oceanic-continental convergence



Oceanic-oceanic convergence

Convergent Boundaries

Continent-continent convergence
Folded mountains

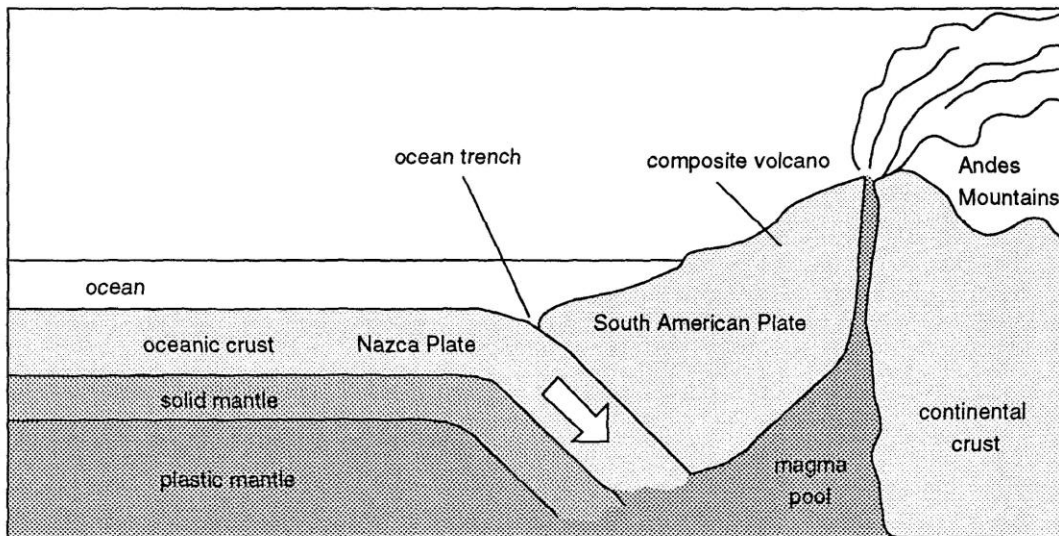


Ex Himalayas
Eurasian/Indian plates



Convergent Boundaries

- **Subduction Zones:** where ocean plates slide under another plate
- Creates magma which moves upward, pushing up the land above it.
- Heat from the magma can change the rock around it. Rock that recrystallizes without melting becomes **metamorphic rock**..



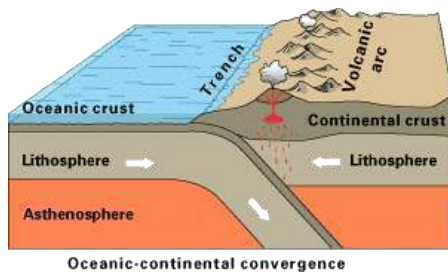
Denser oceanic plates always subduct beneath less dense continental plates

Fig. 8-3. Subduction of the Nazca Plate below the South American Plate forming composite volcanoes

Convergent Boundaries

Ocean-continent convergence

Trench & Coastal Volcanoes



Convergent Boundaries

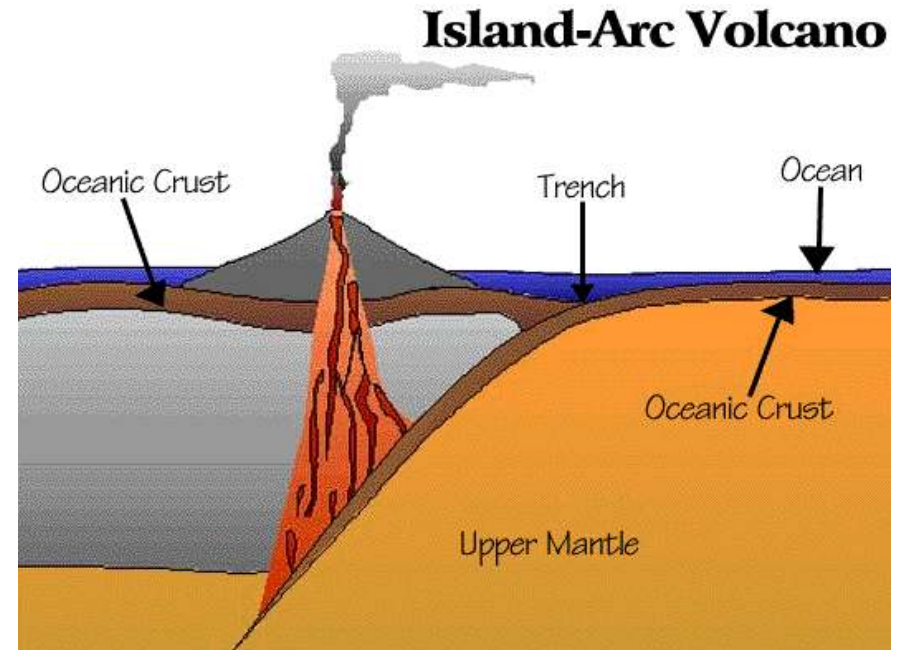
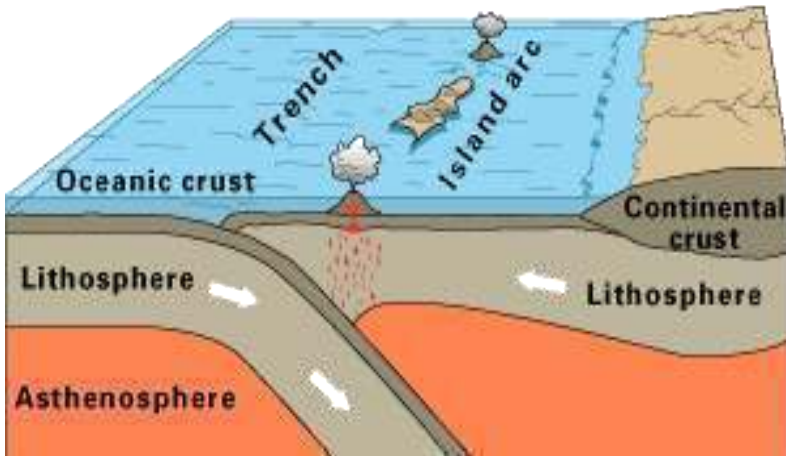
Ocean-continent convergence



Convergent Boundaries

Ocean-ocean convergence

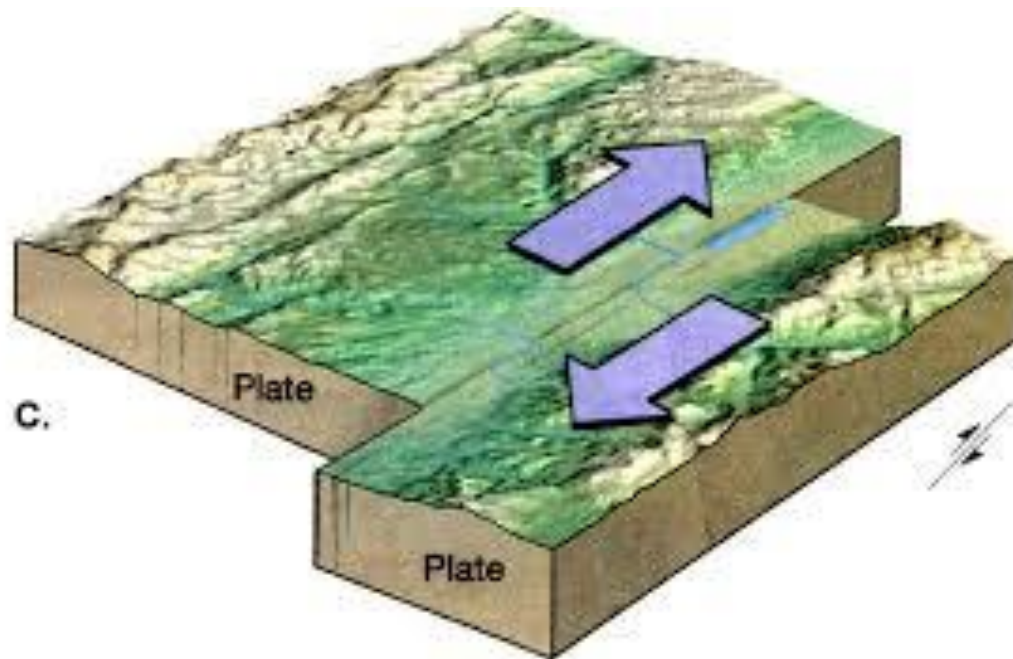
Trench & Island arc



Transform plate boundary

- Crust is neither created nor destroyed

Plates slide past one another



Transform plate boundary

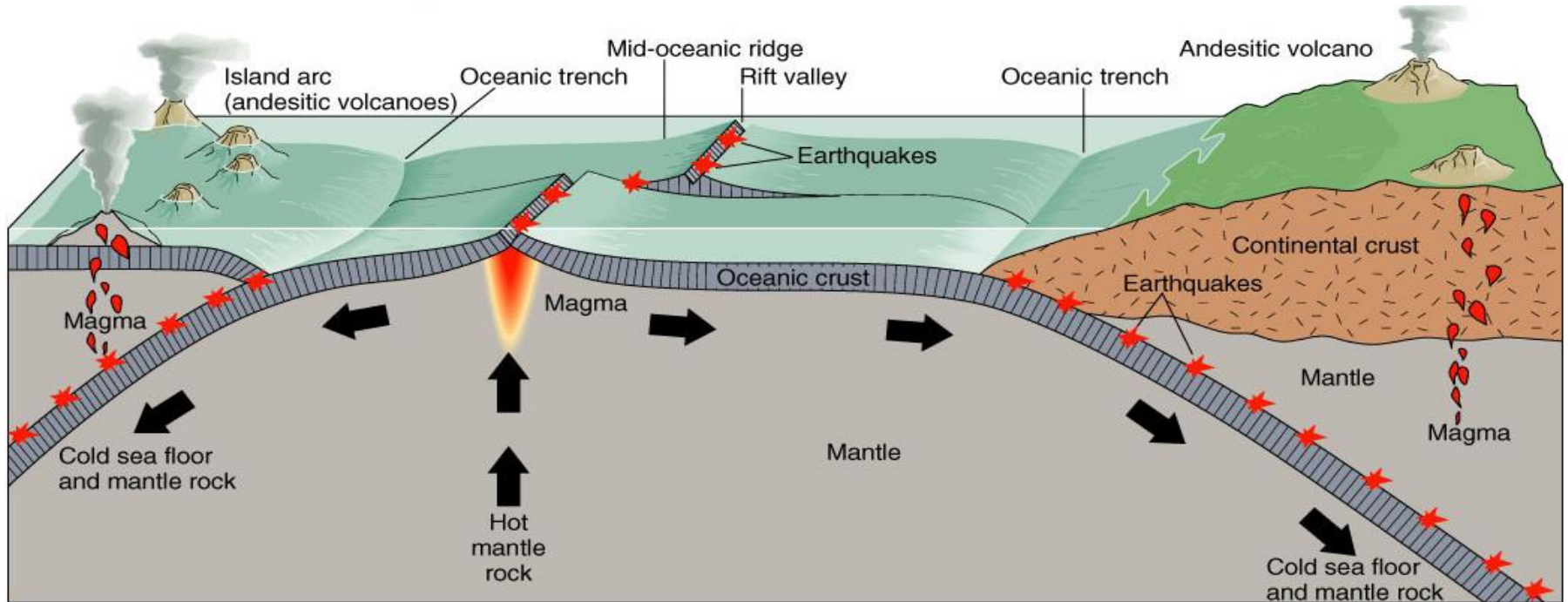


San Andreas Fault



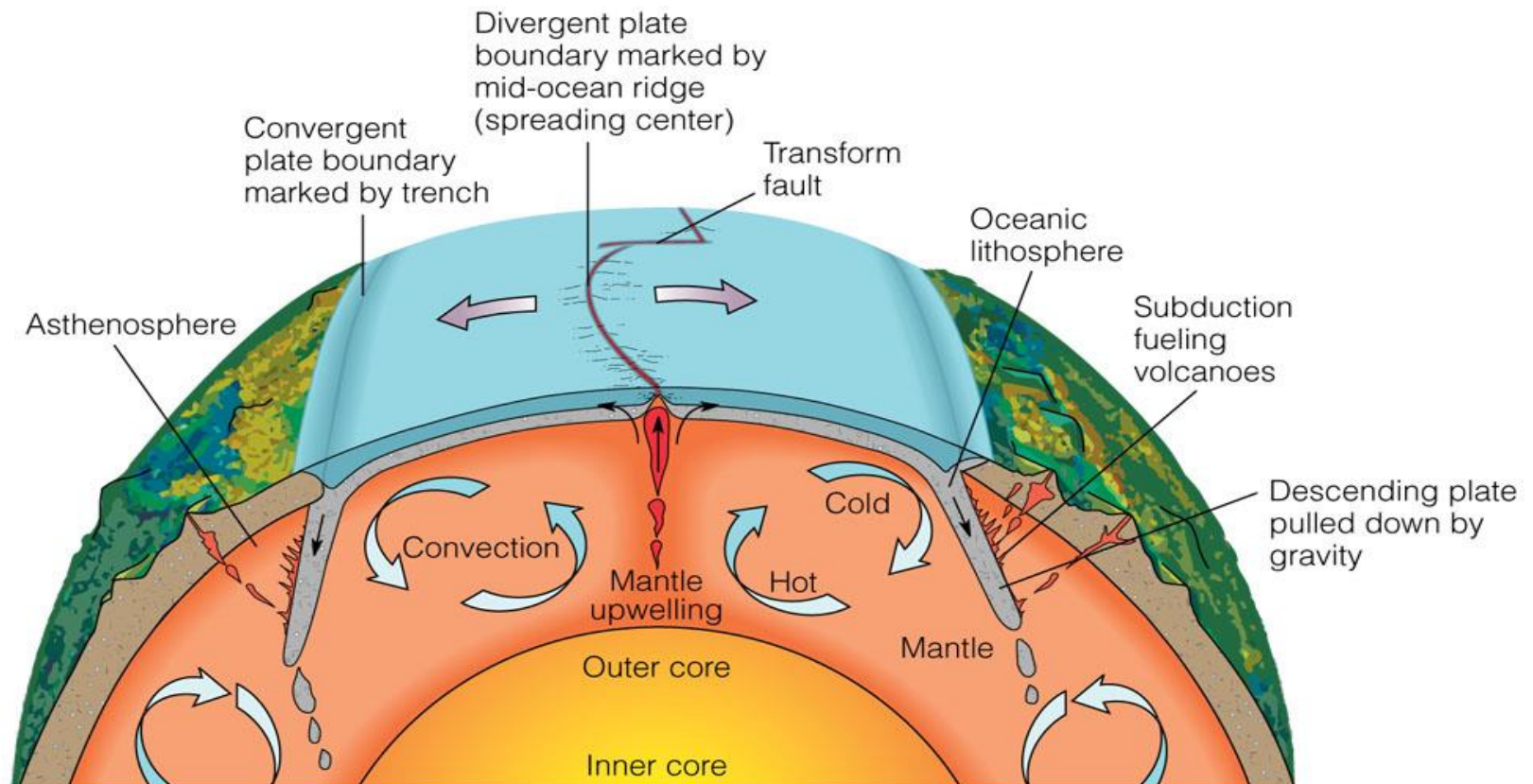
Carrizo Plains, Central California

Summary of Plate Movements



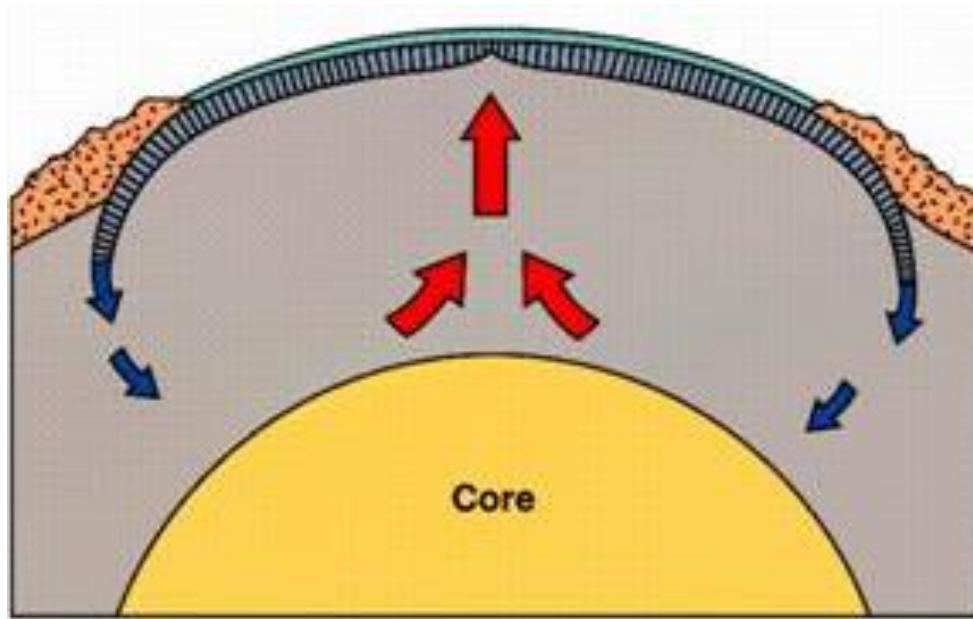
Convection currents

In 1960`s convection currents has been proposed as driving force to move continents



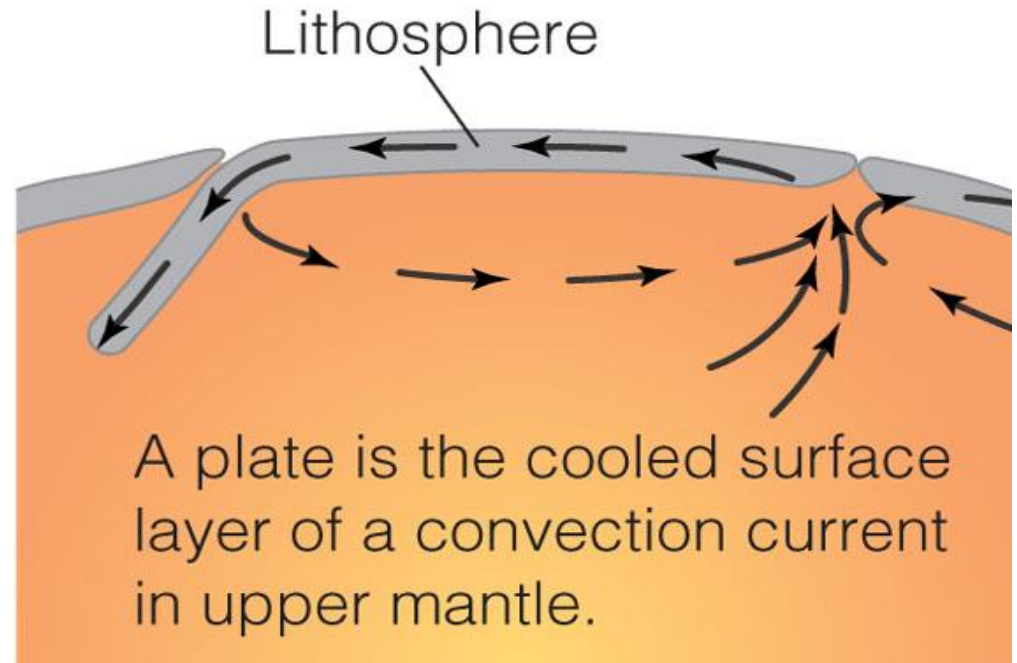
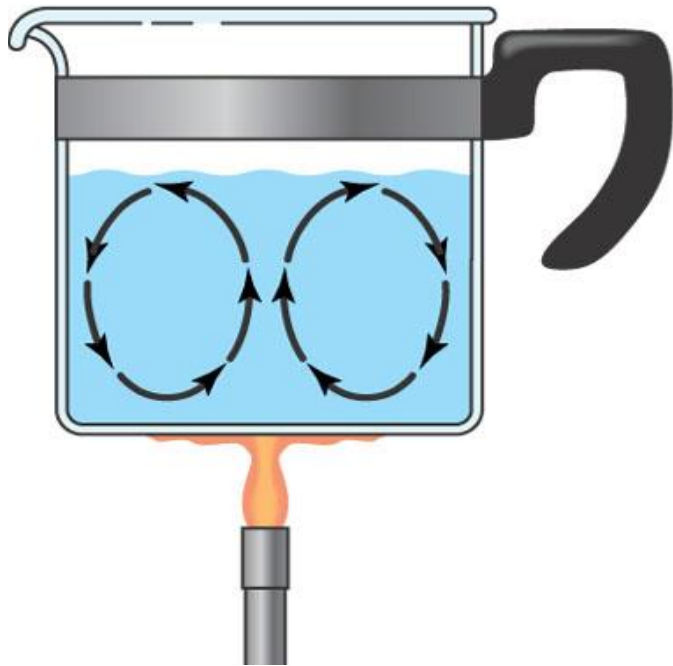
Convection currents

Driving force for convection?



Movement of matter is driven by Earth's internal and external sources of energy

Convection currents



How deep does the convection occurs?

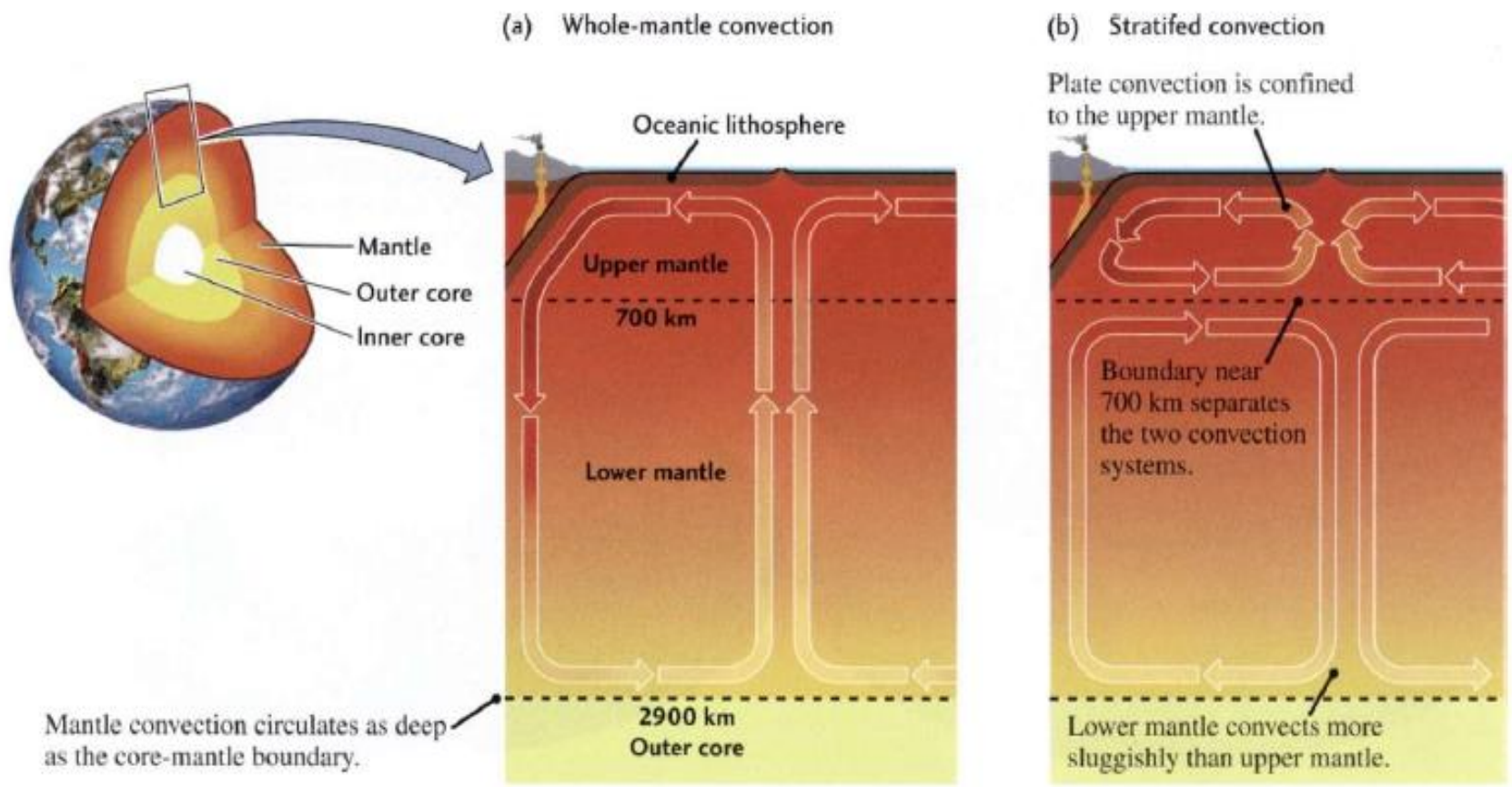


Figure 2.14 Two competing hypotheses for the mantle convection system.

Two competing hypotheses for the mantle convection system

Rates and History of plate movements

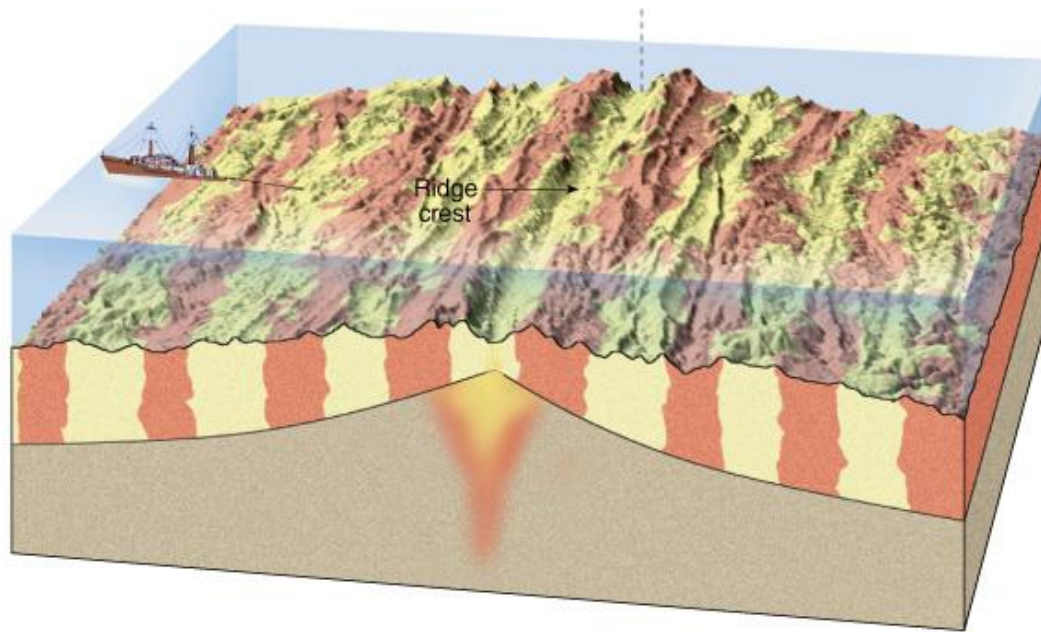
How fast do plates move?

Do some plates move faster than others, and if so, why?

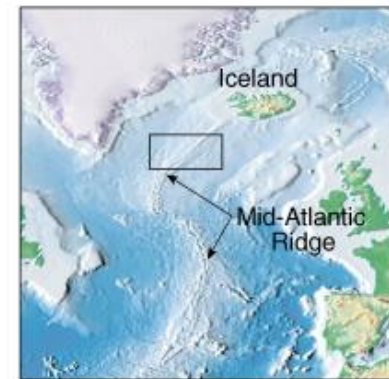
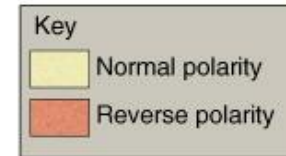
Is the velocity of plate movements today the same as it was in the Geologic past?

Rates and History of plate movements

Paleomagnetism

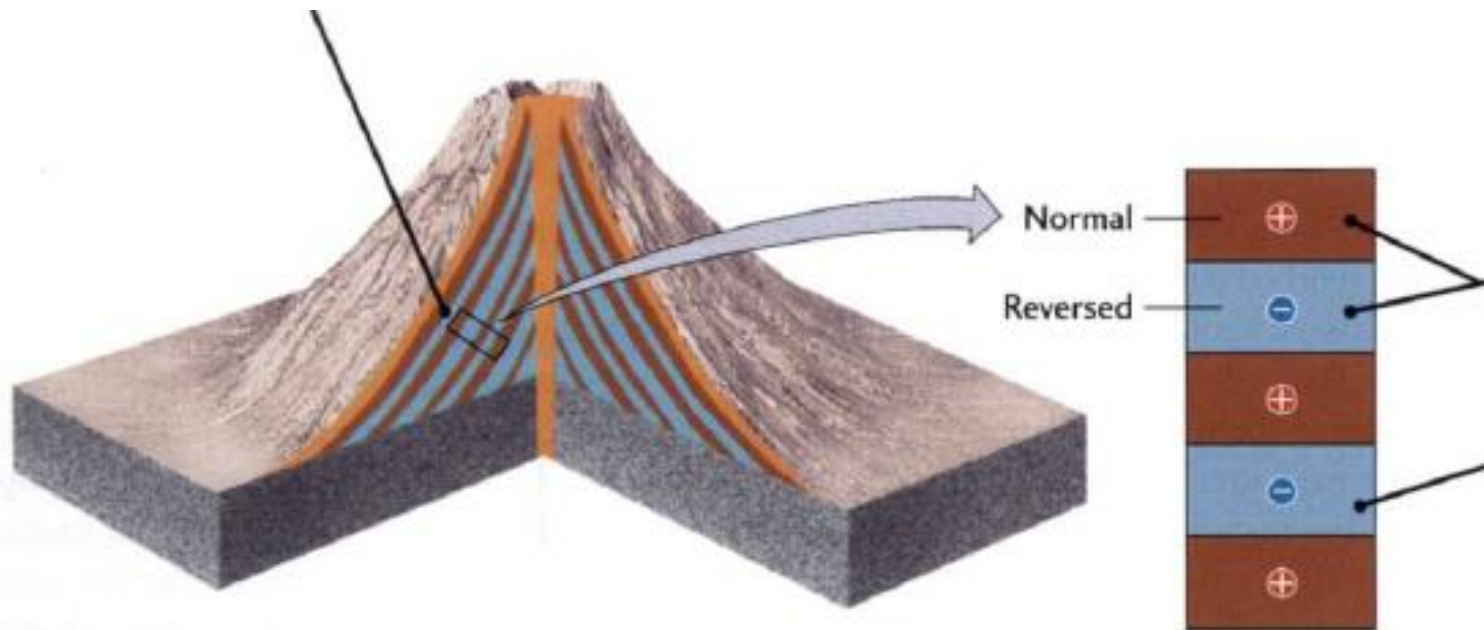


B. Research vessel towing magnetometer across ridge crest

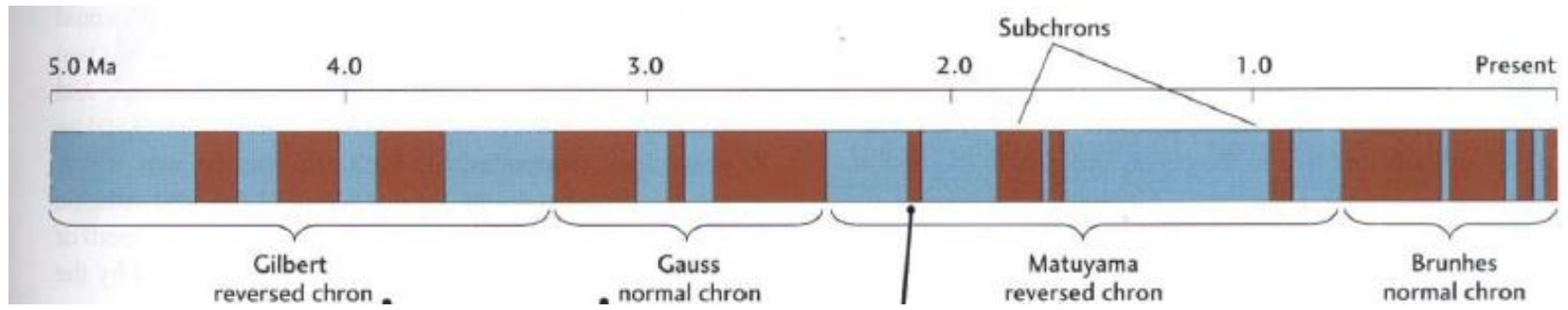


C. Location map

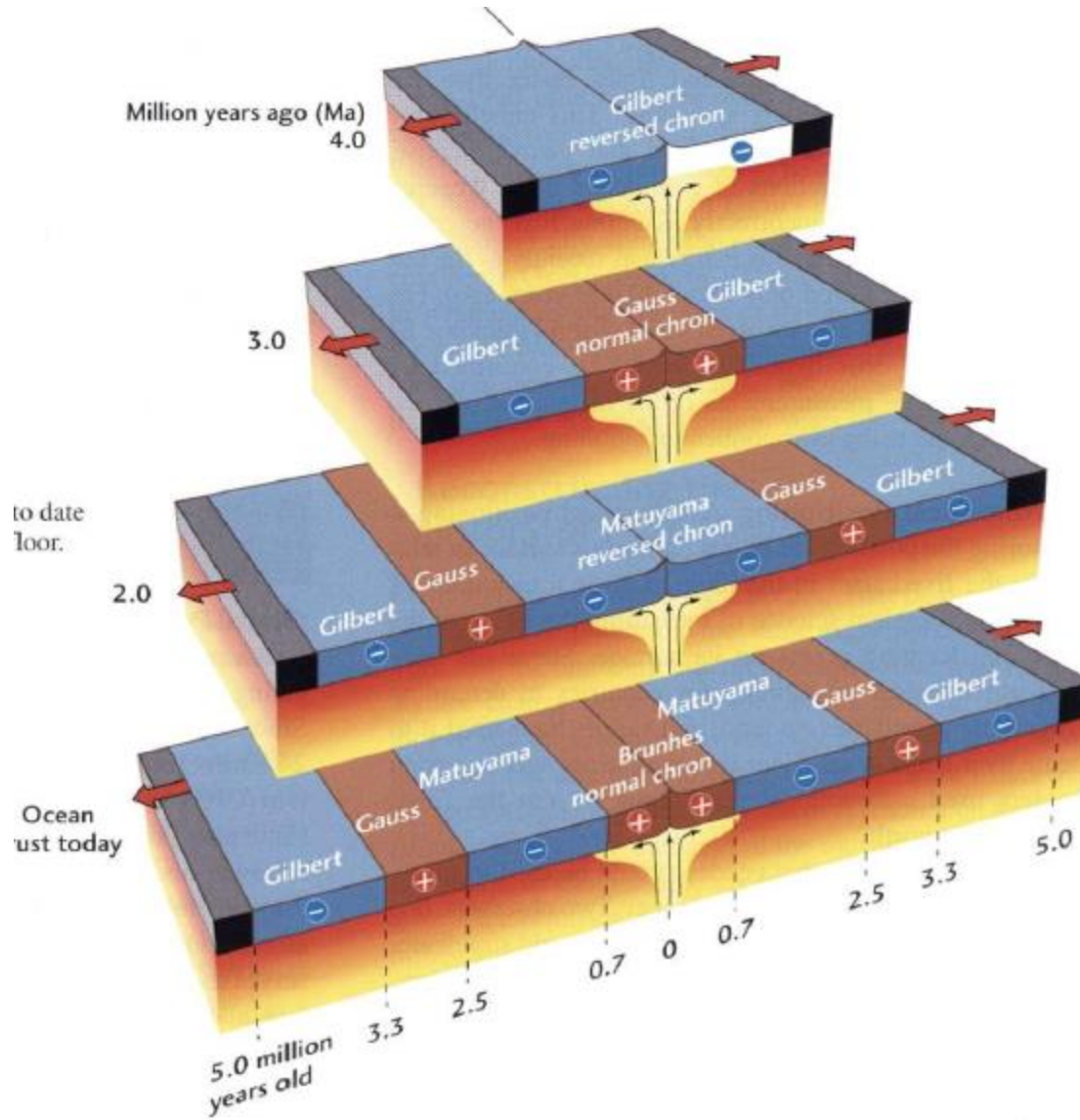
Paleomagnetism



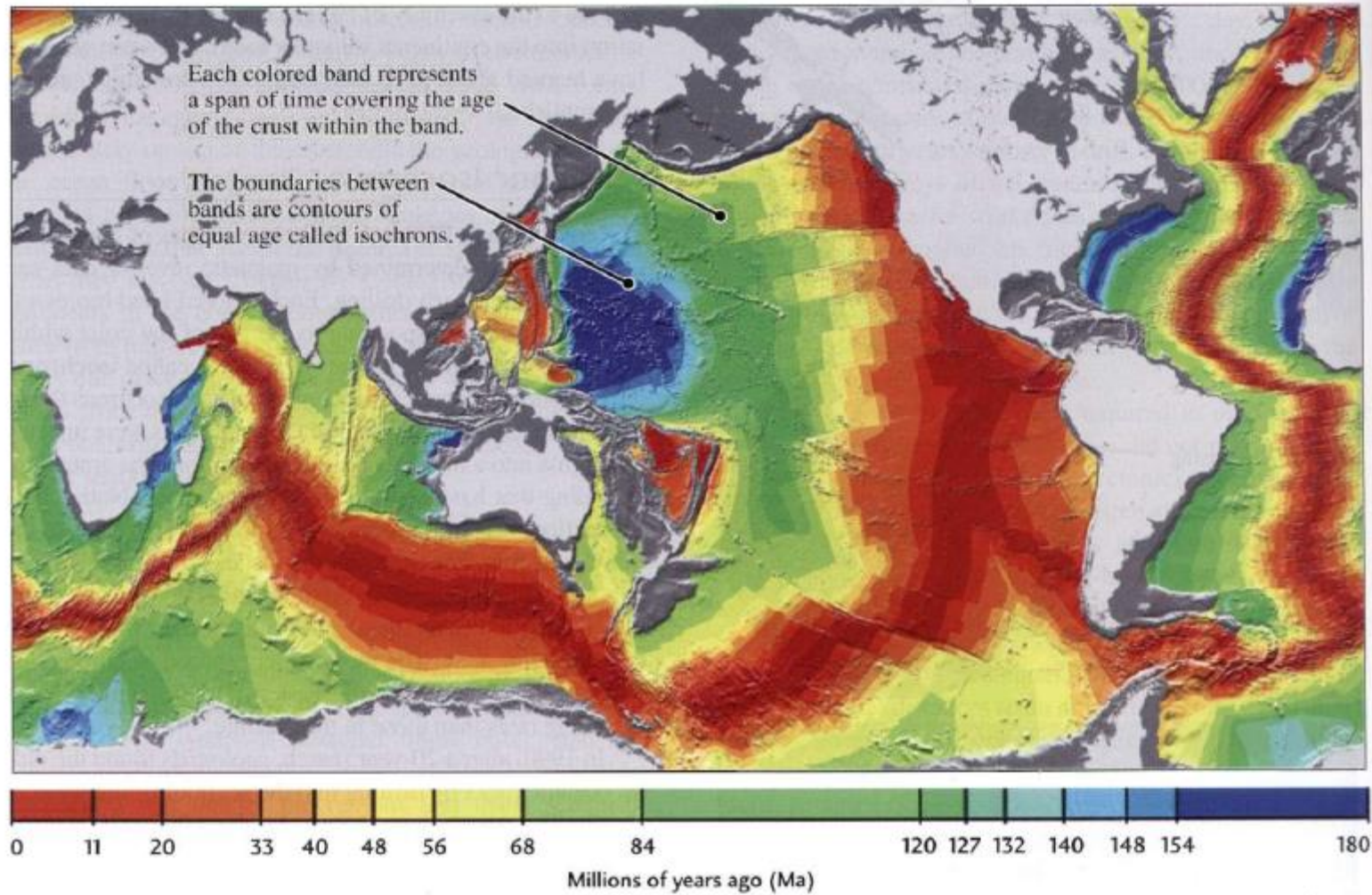
Paleomagnetism



Paleomagnetism



The global isochron map of the ocean floor



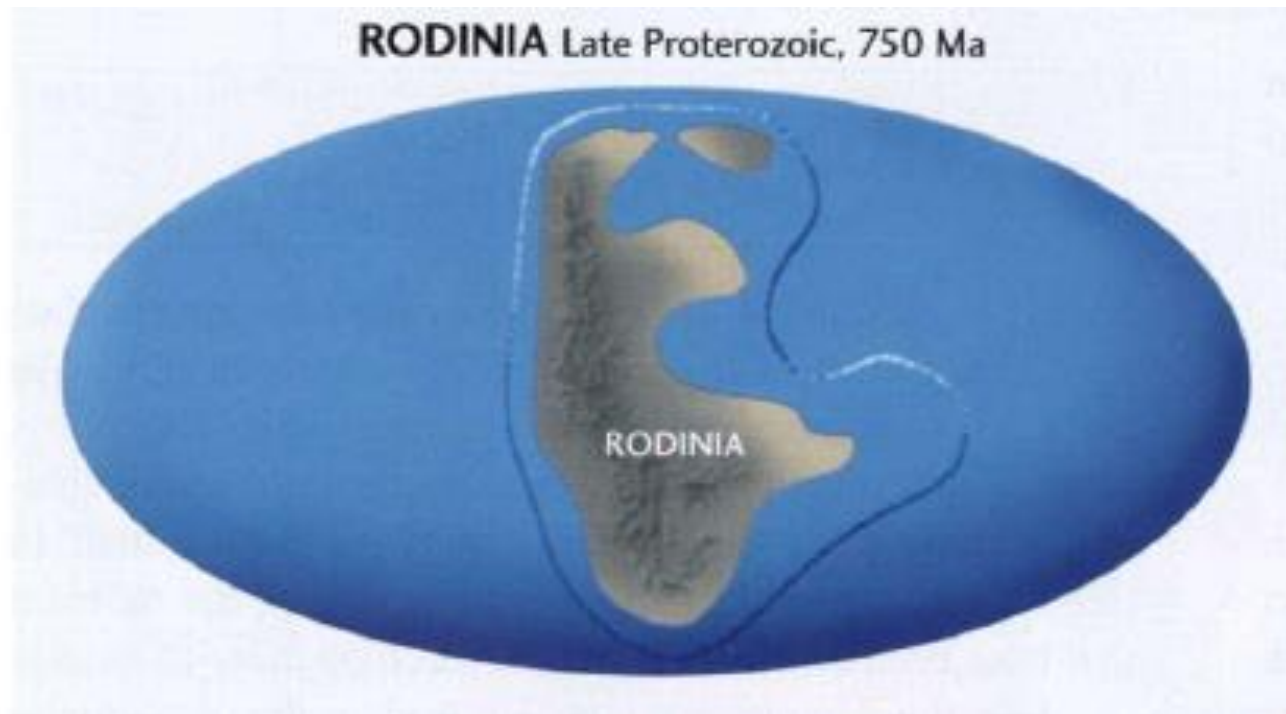
Reconstructing history of plate movements

- Sea floor isochron

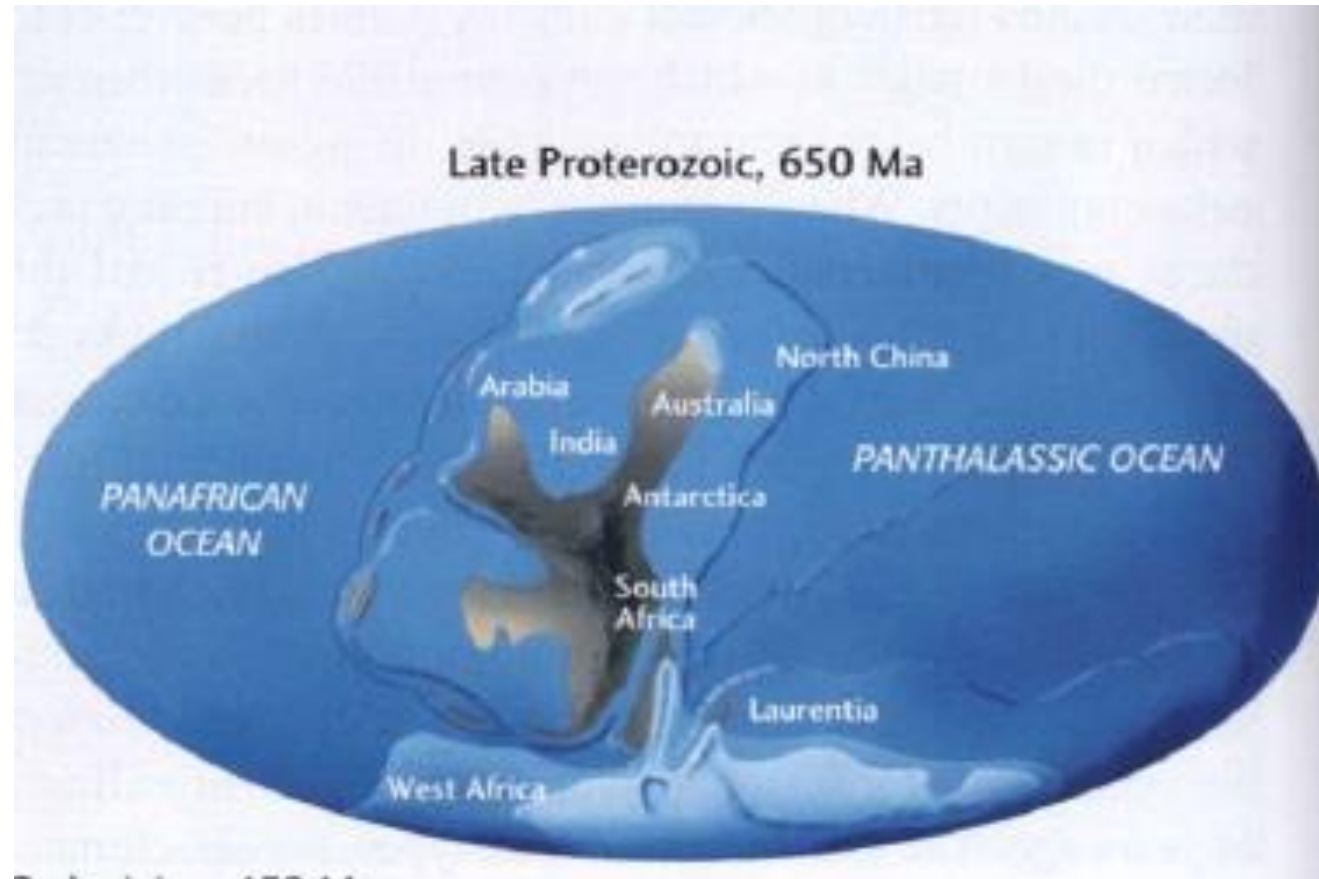
- Transform fault boundaries

- Evidences also derived from rock types, fossils, mountain belts etc

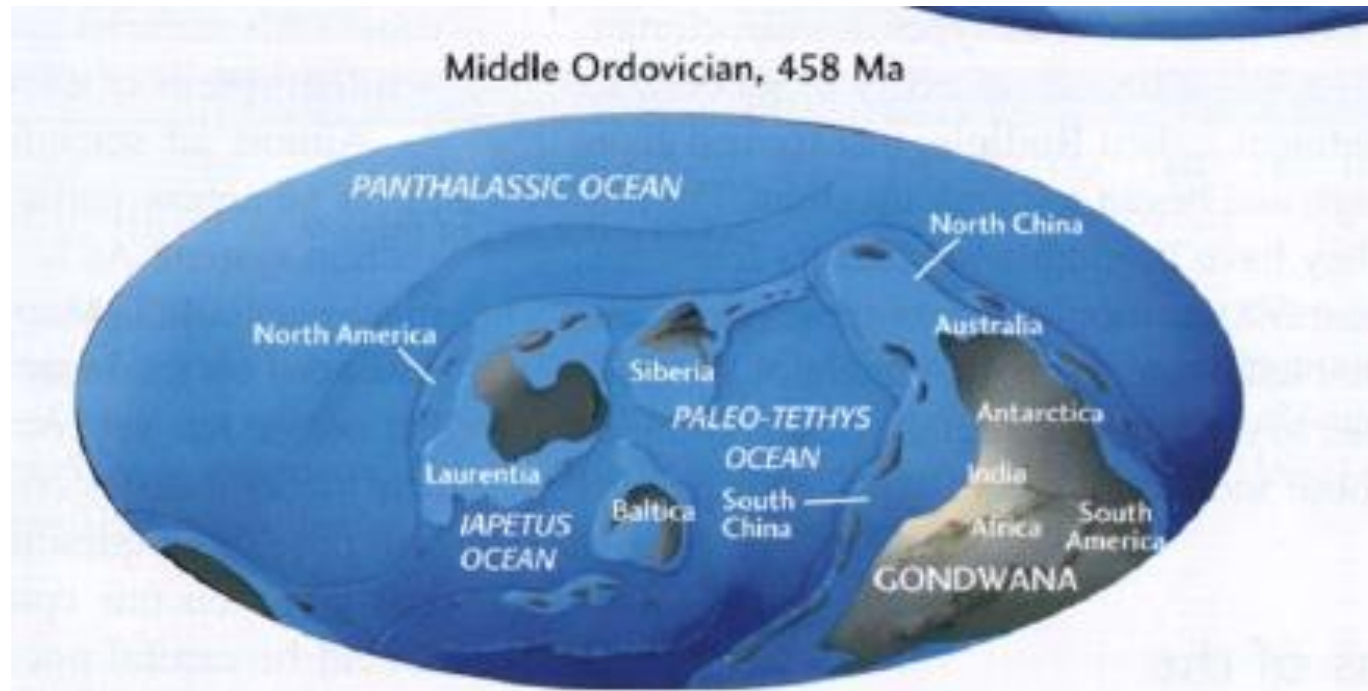
Assembly of Pangaea



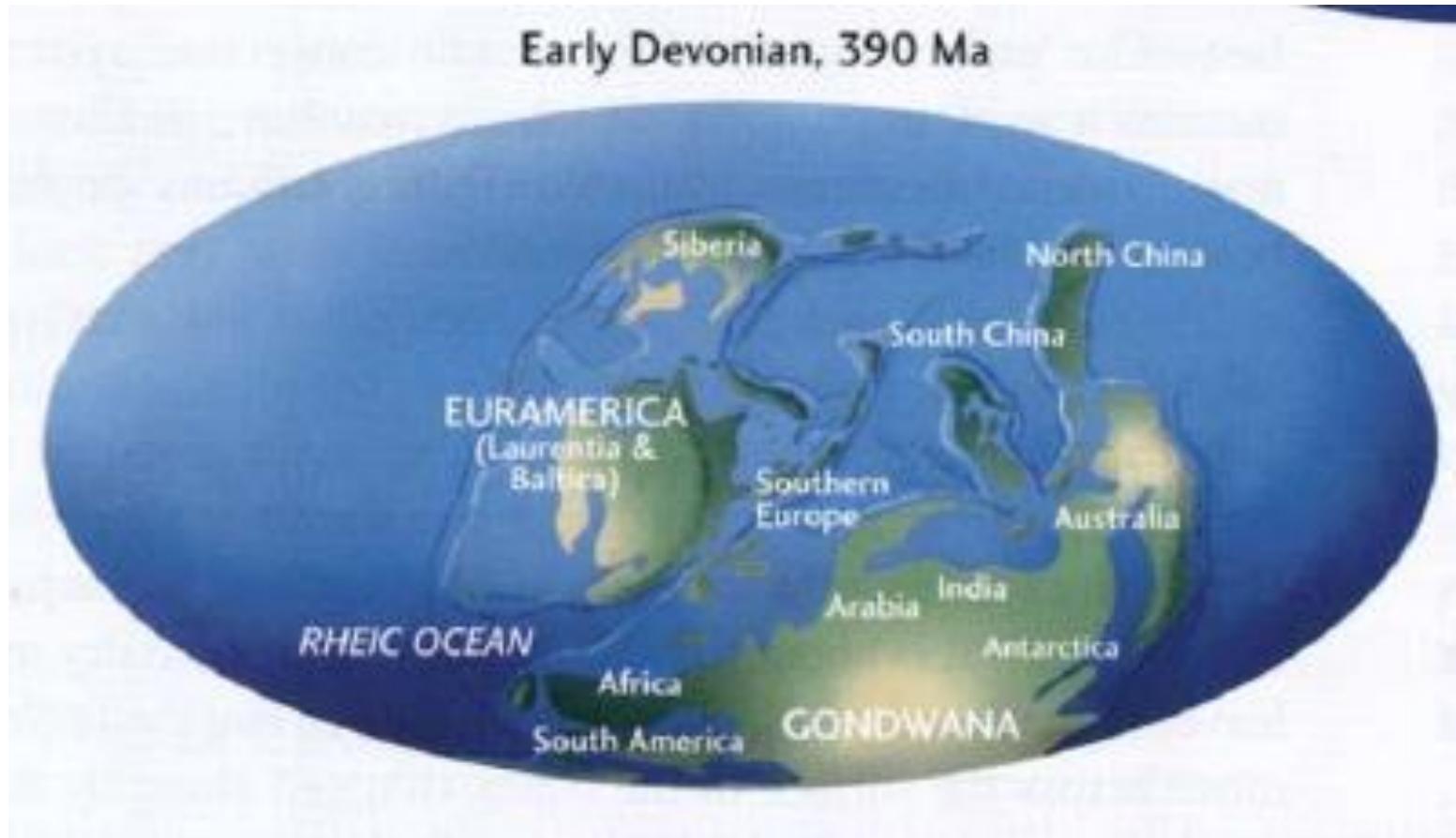
Assembly of Pangaea



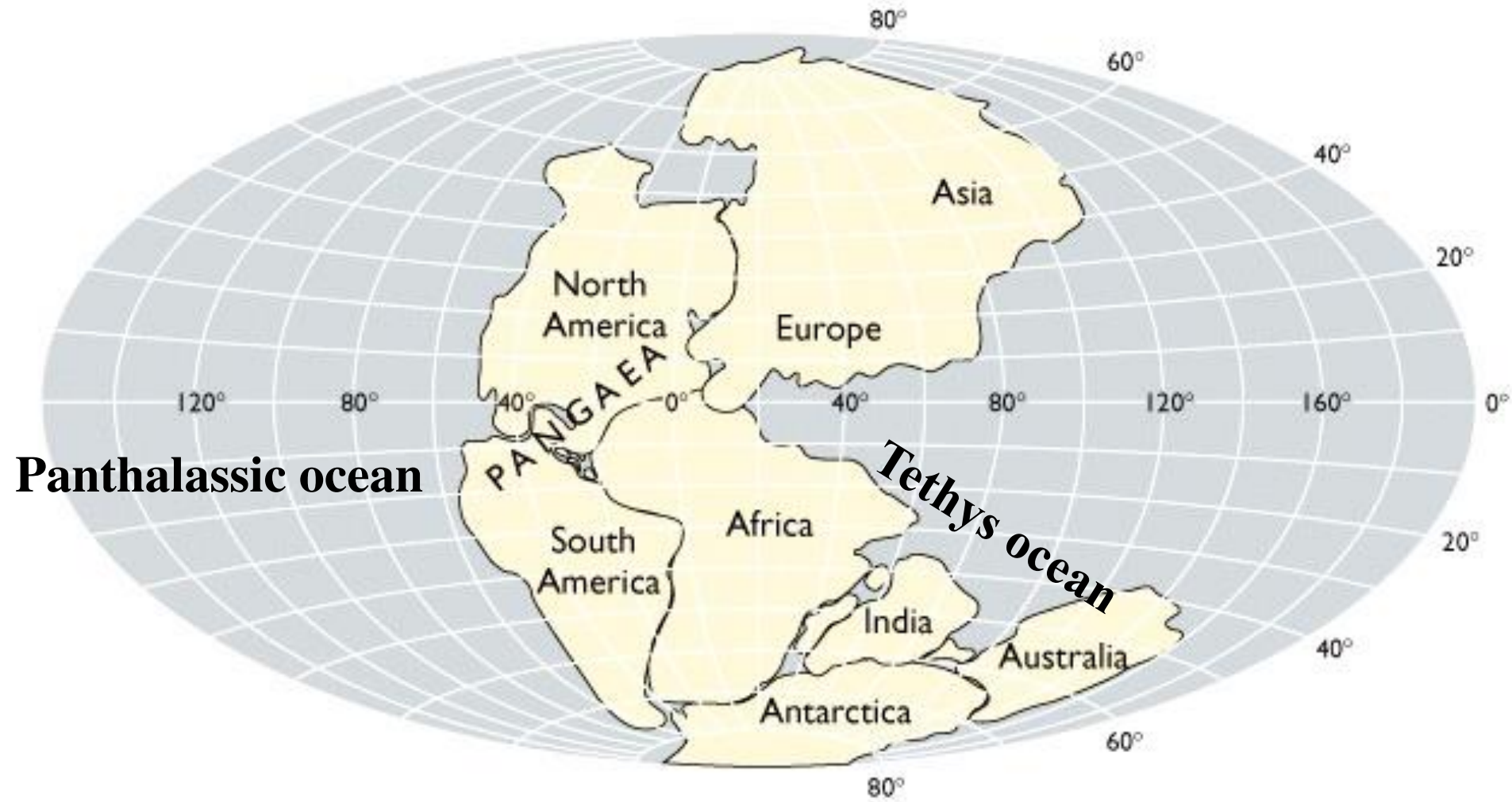
Assembly of Pangaea



Assembly of Pangaea

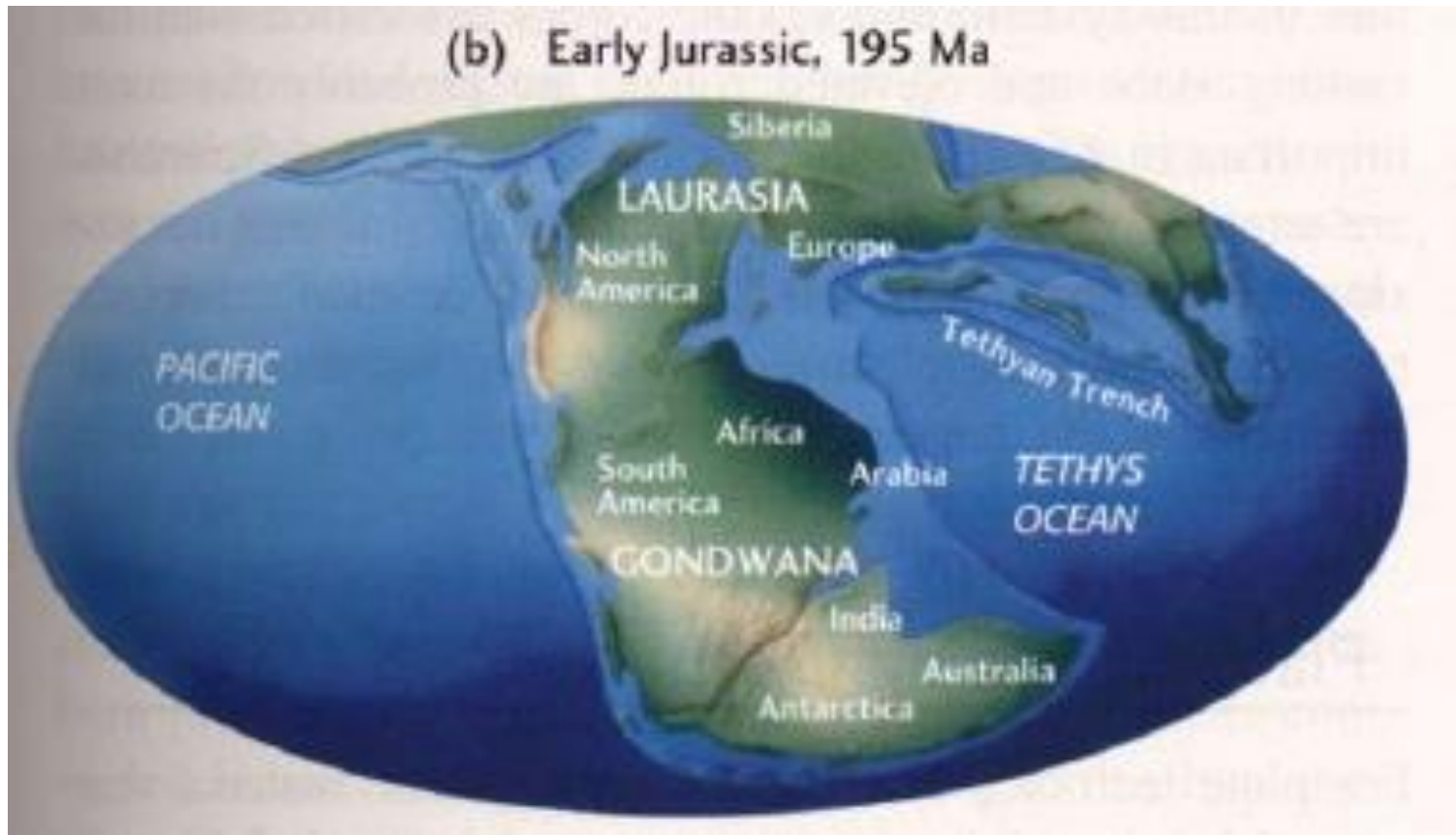


THE SUPERCONTINENT OF PANGAEA (237 MILLION YEARS AGO)



Break up of Pangaea

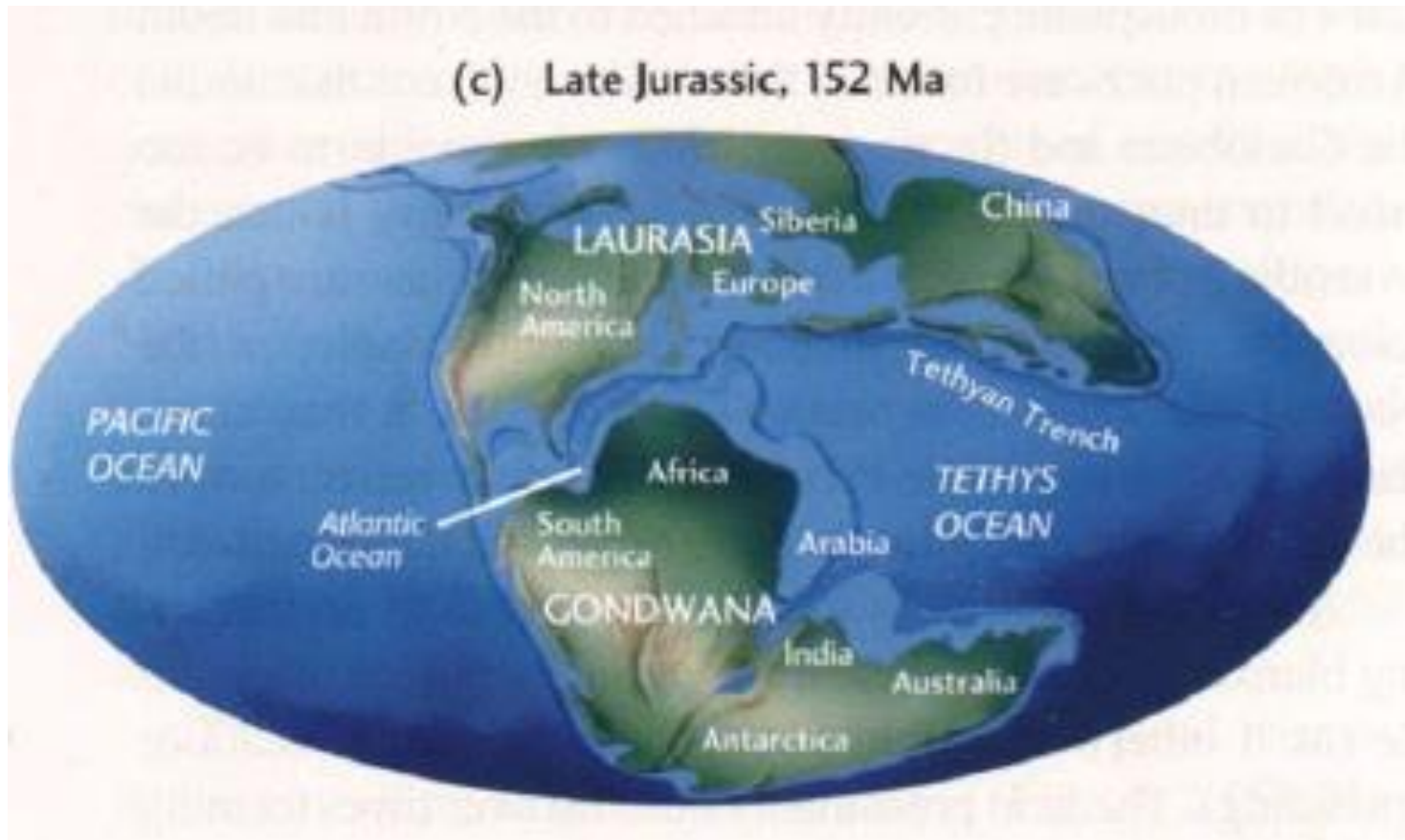
Evidence-rift system-volcanic rocks from Nova Scotia and North Carolina



Break up of Pangaea

Early stage of break up- Atlantic ocean opened up and Tethys sea contracted

-Southern continents and northern continent split up

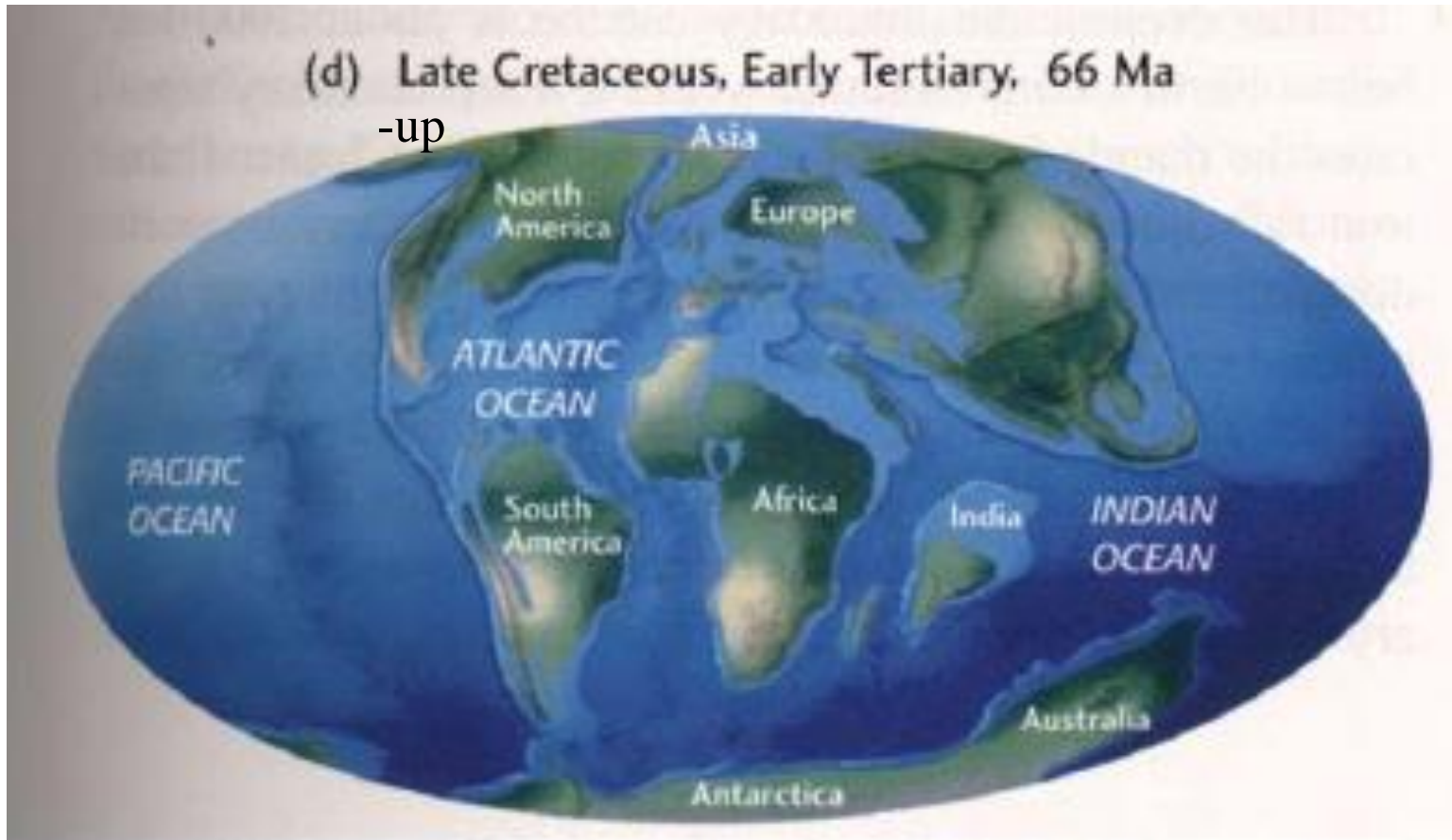


Break up of Pangaea

Early stage of break up- Atlantic ocean opened and widened

-Tethys ocean was closing to form Mediterranean

- India was well going northward



The present day and future world

(e) PRESENT-DAY WORLD



- 7 The modern world has been produced over the past 65 million years. India collided with Asia, ending its trip across the ocean, and is still pushing northward into Asia. Australia has separated from Antarctica.

(f) 50 million years in the future

