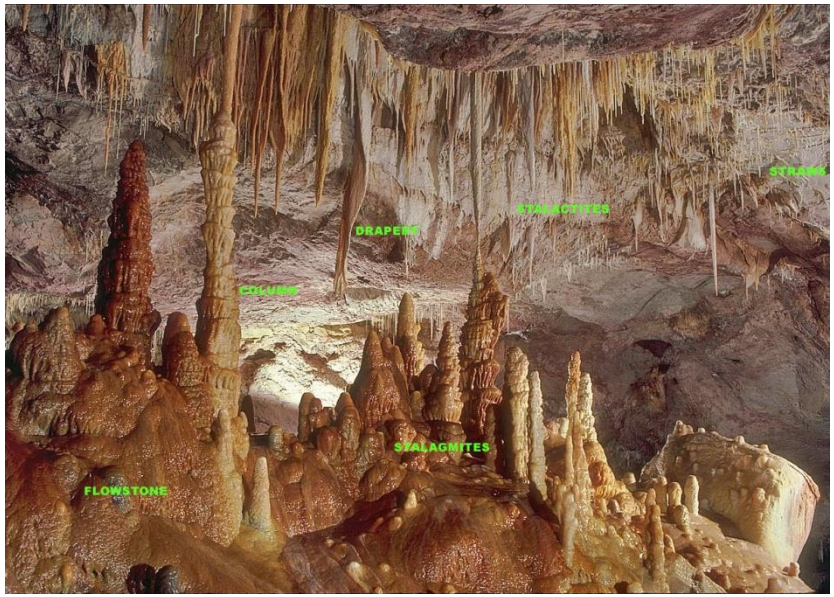
# IDC 203: INTRODUCTION TO EARTH SCIENCES



# 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.
- Plates tectonic 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

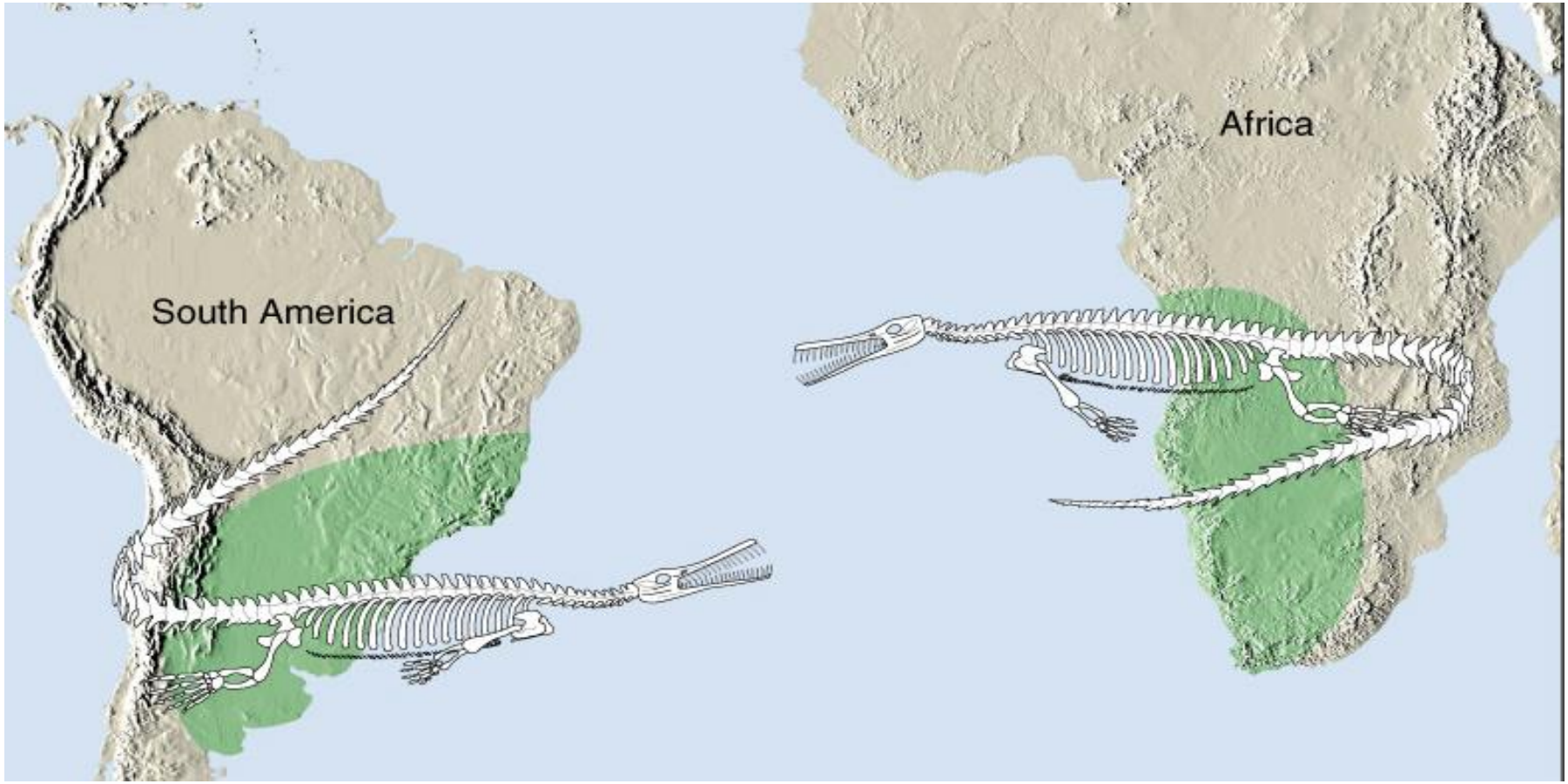
# Evidence of Continental drift

## Geographic fit


**Continents seem to fit together like pieces of a puzzle**

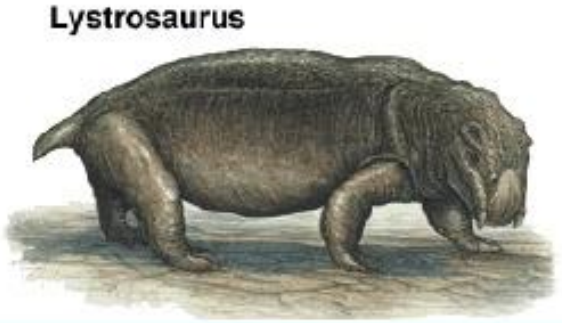
# Evidence of Continental drift

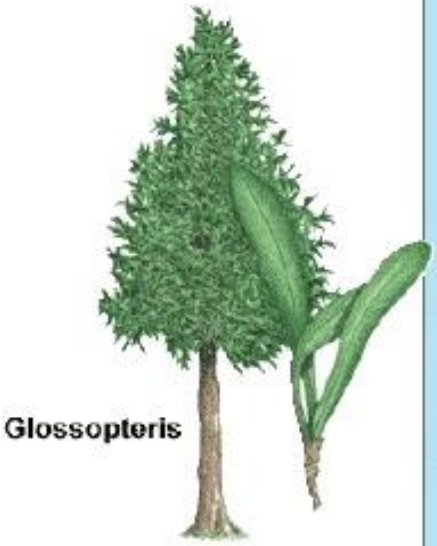
## Fossils

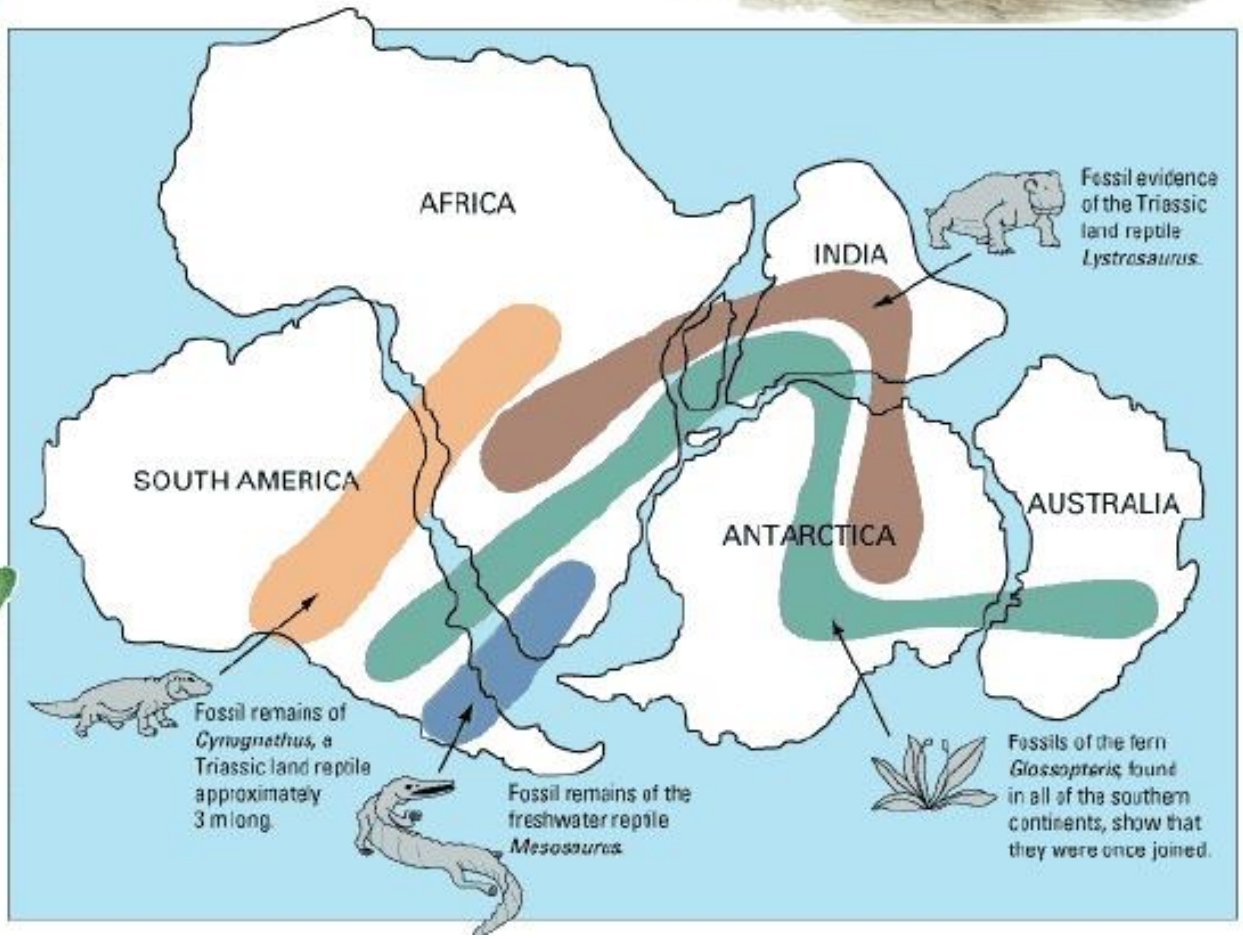



Similar distribution of fossils such as the *Mesosaurus*

# Fossil Evidence for Continental Drift

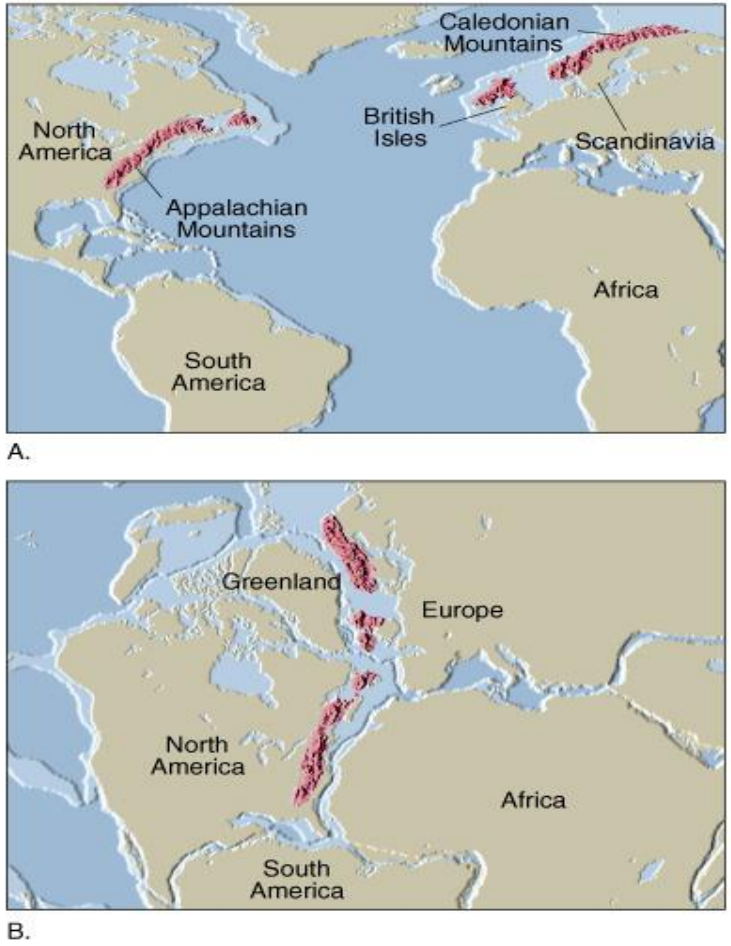



# Glossopteris

# Evidence of Continental drift

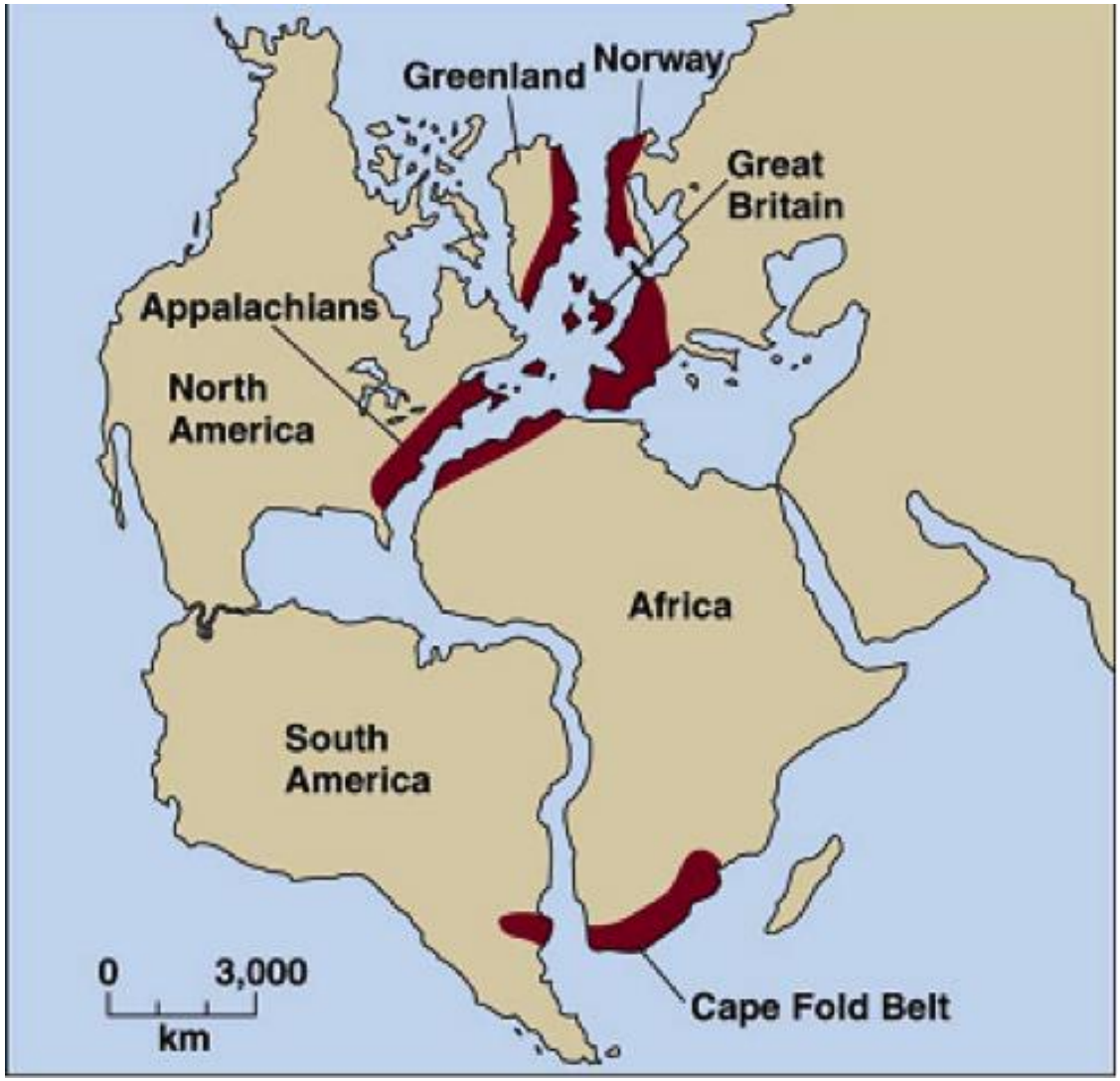
## Mountain chain




Mountain ranges match across oceans

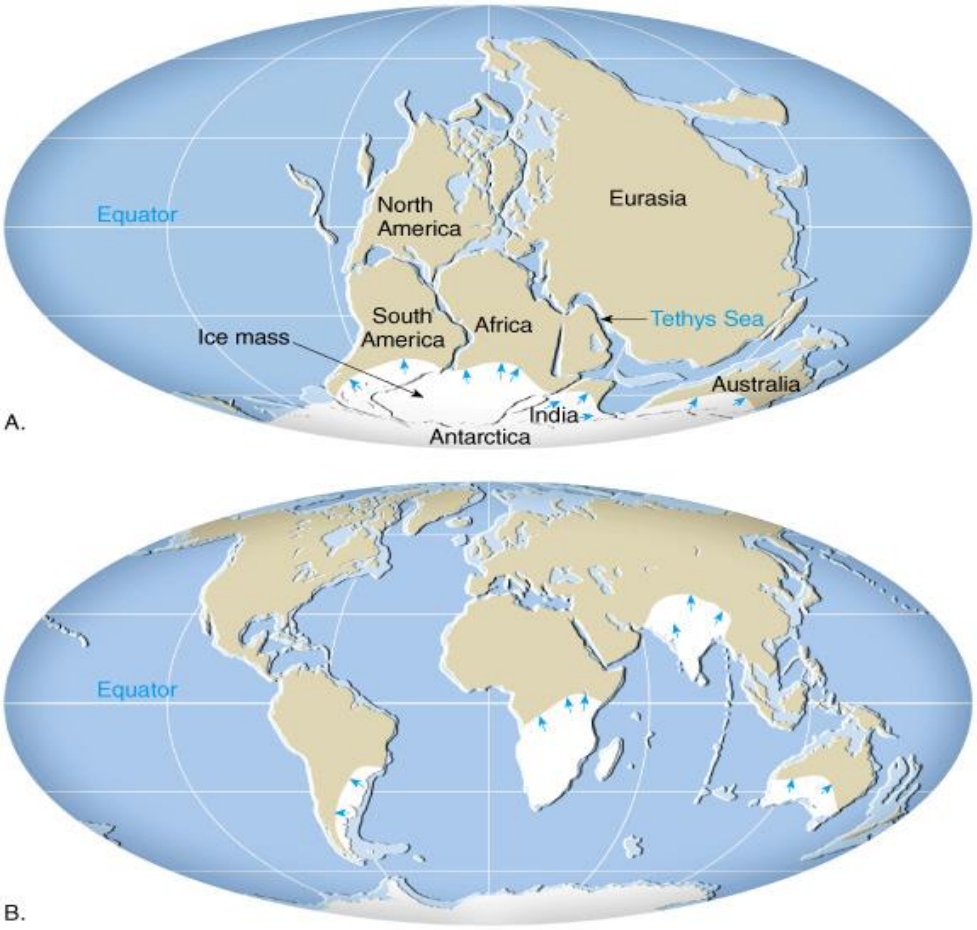
# Evidence of Continental drift

## Rock types



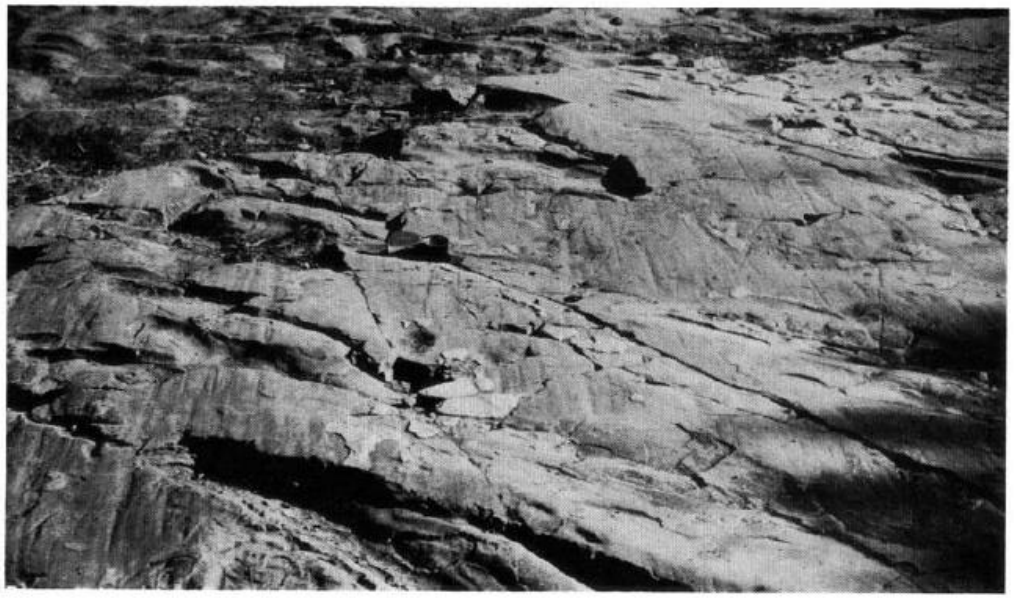
# Evidence of Continental drift

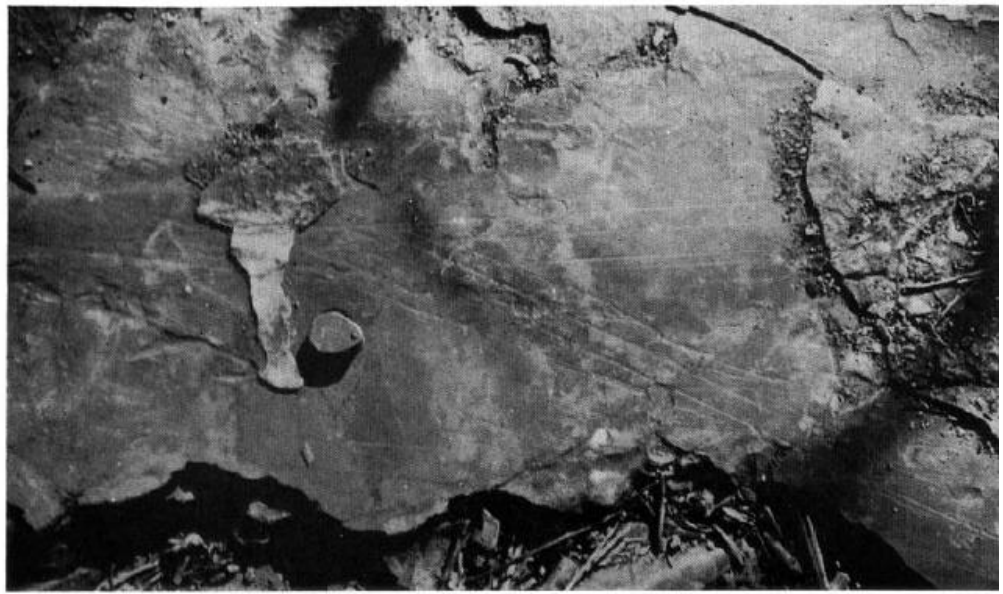
## Glaciers

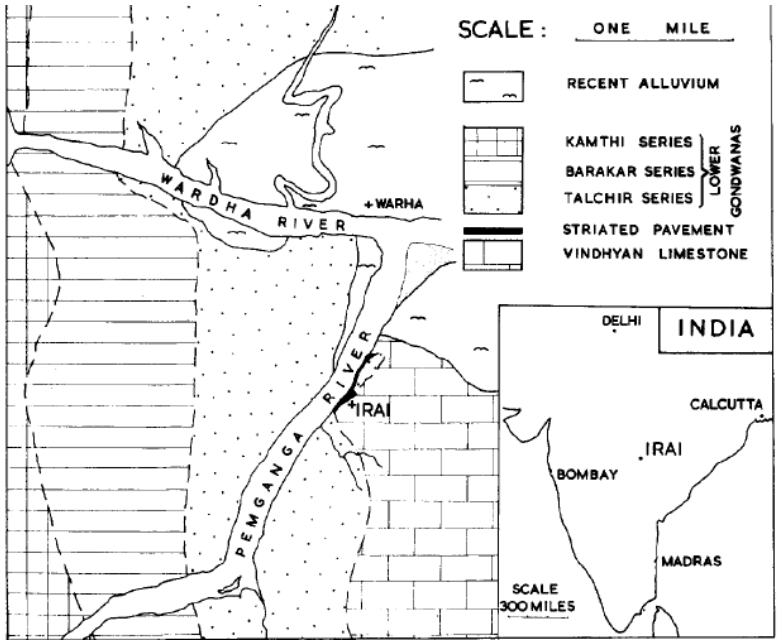



Glacial ages and climate evidence

# EVIDENCE FOR A TALCHIR (LOWER GONDWANA) GLACIATION: STRIATED PAVEMENT AND BOULDER BED AT IRAI, CENTRAL INDIA[1]

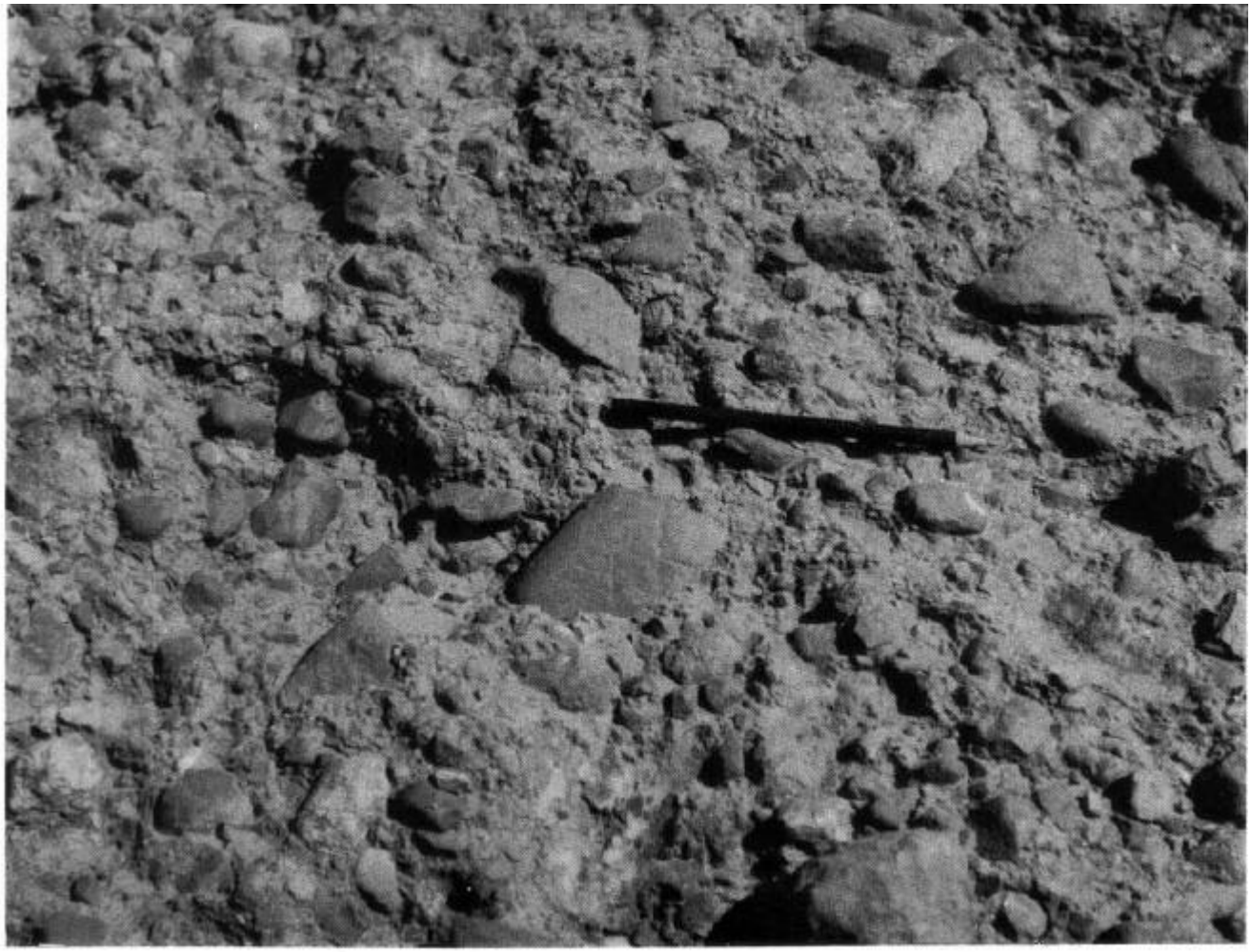







Source: Smith, 1963

# EVIDENCE FOR A TALCHIR (LOWER GONDWANA) GLACIATION: STRIATED PAVEMENT AND BOULDER BED AT IRAI, CENTRAL INDIA[1]



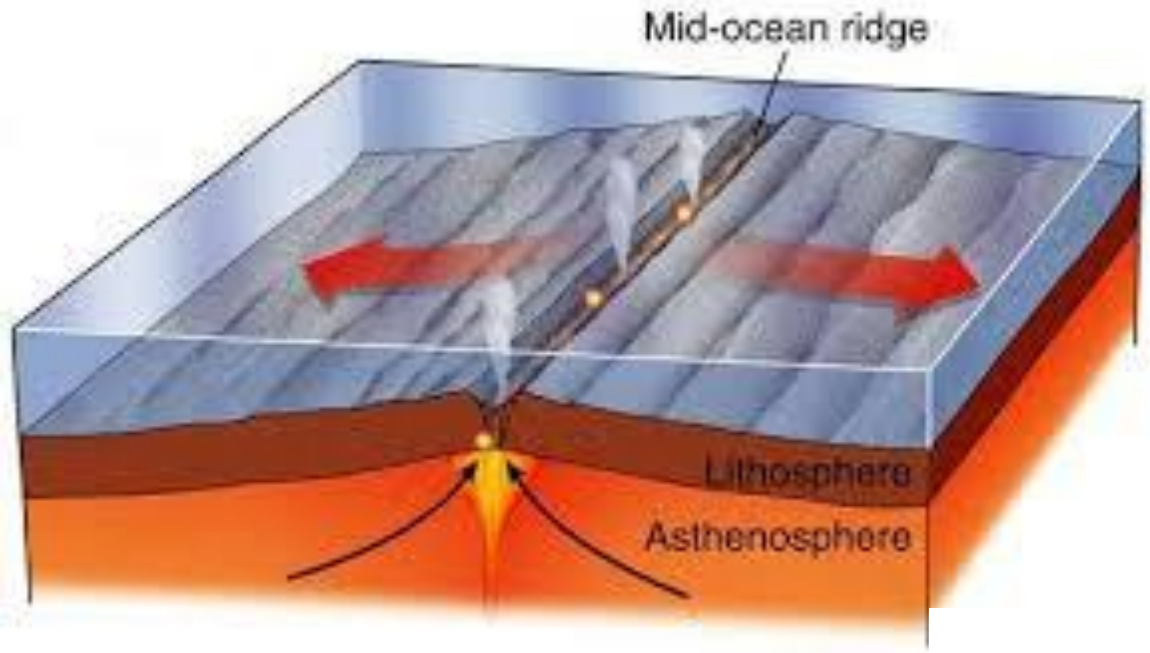
# Rejection and acceptance of Continental drift

- 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

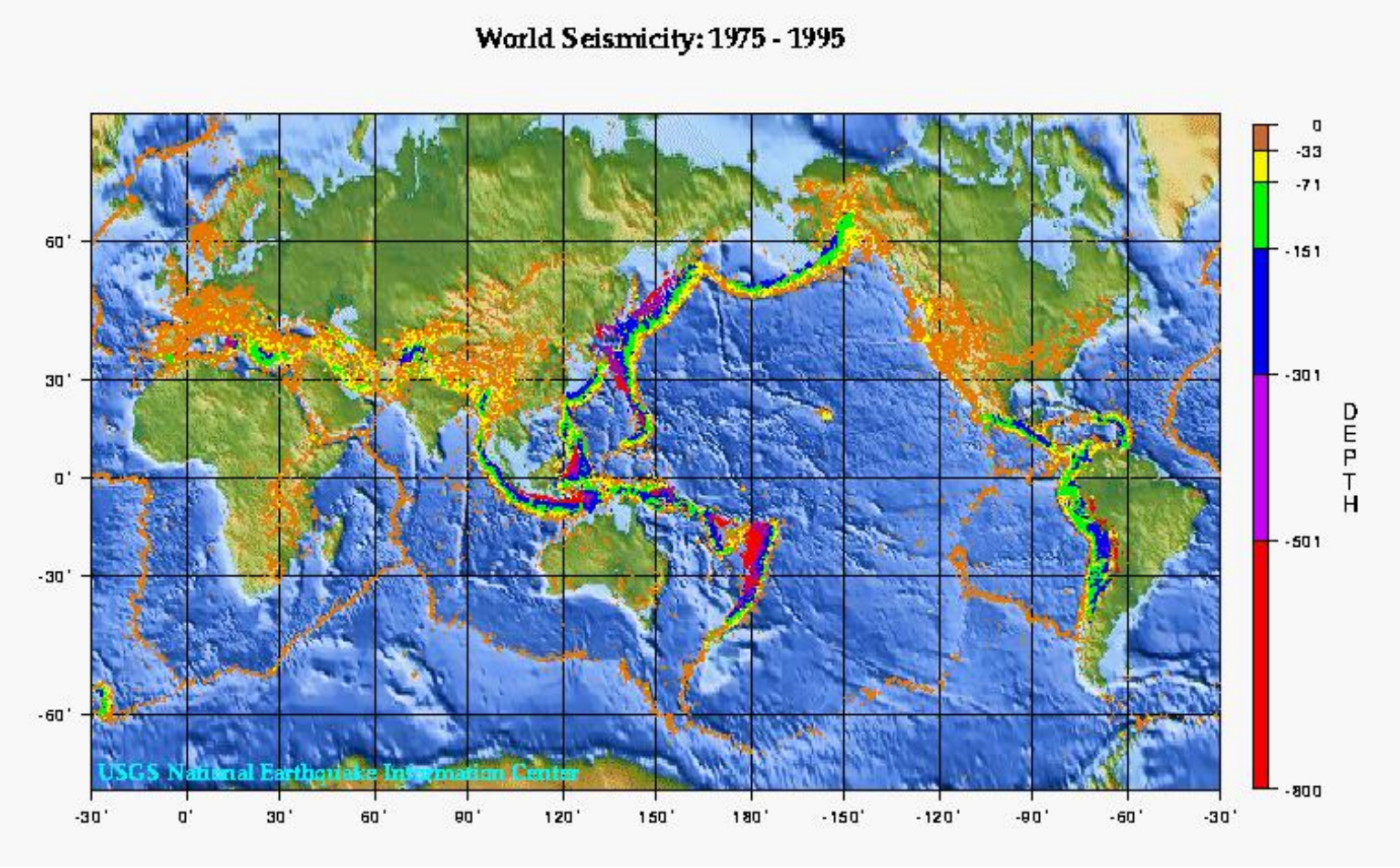
- Continental drift reexamined in 1960's with new information
- Supporting evidence for seafloor spreading
  - World seismicity
  - Volcanism
  - Age of seafloor
  - Paleomagnetism
  - Heat flow

# Mid oceanic ridge



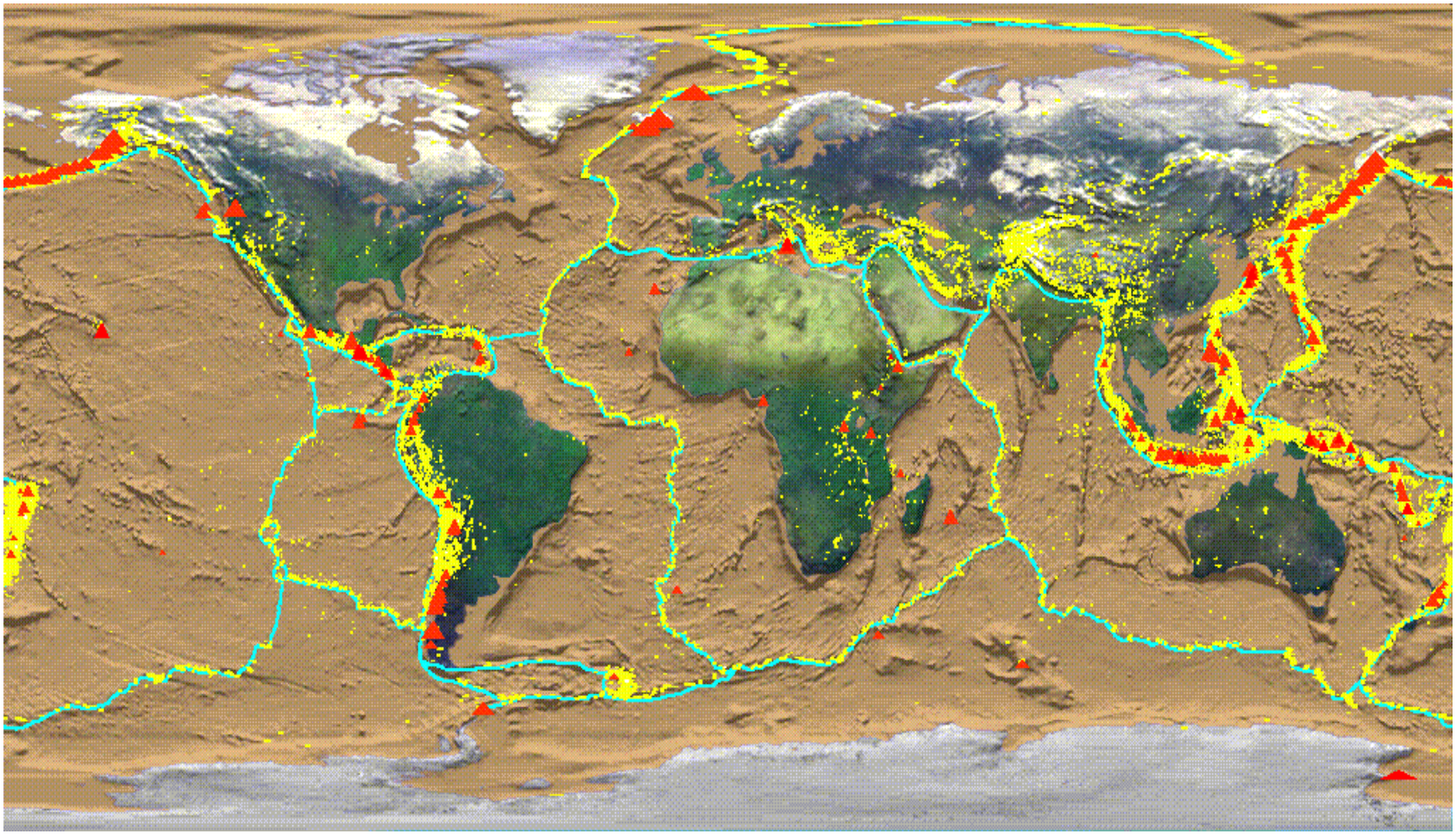

# Evidence of sea floor spreading

## Seismicity



# Evidence of sea floor spreading

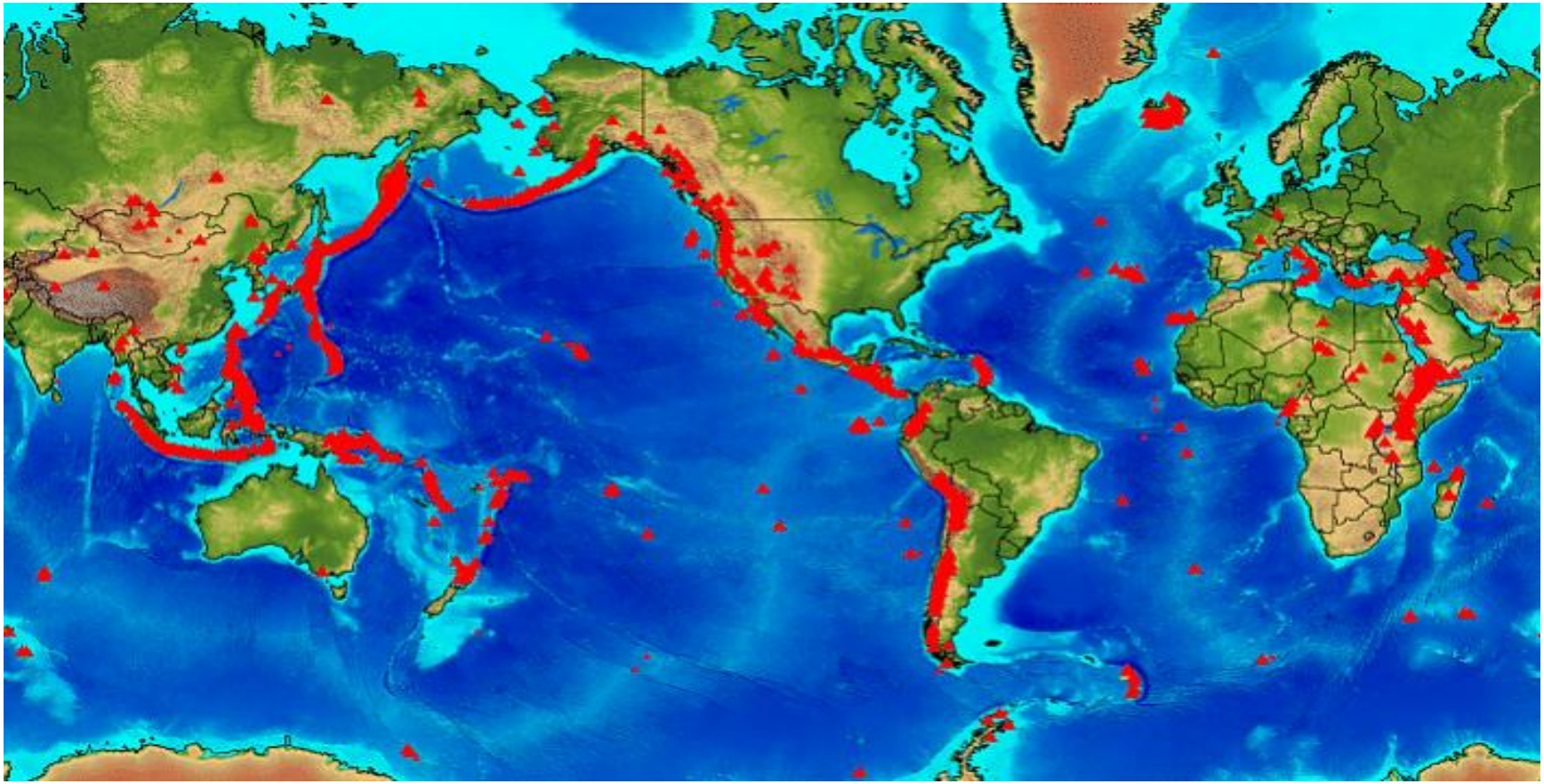
## Seismicity



Earthquake distribution matches plate boundaries

# Evidence of sea floor spreading

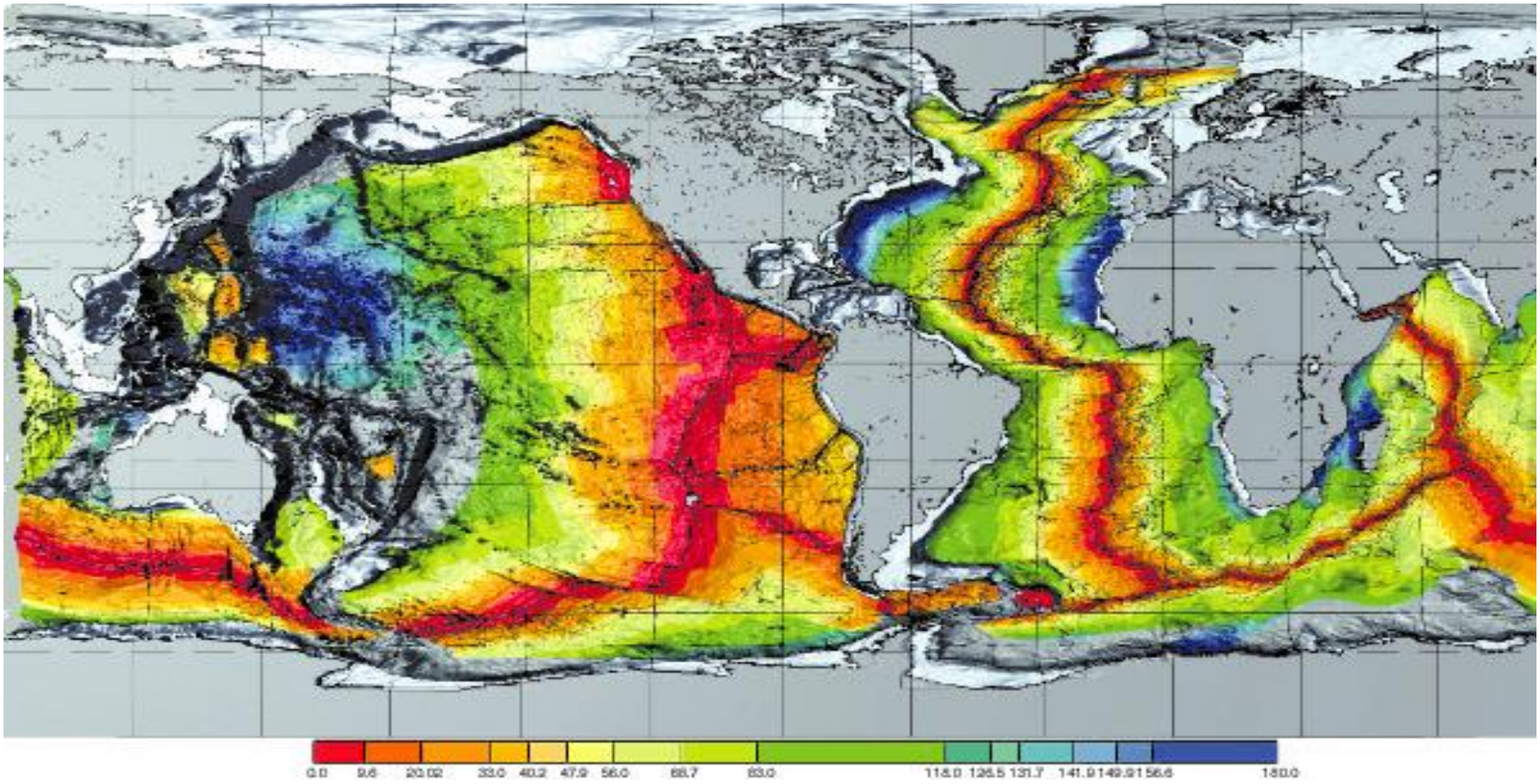
## Volcanism



**Volcanoes match some plate boundaries**

# Evidence of sea floor spreading

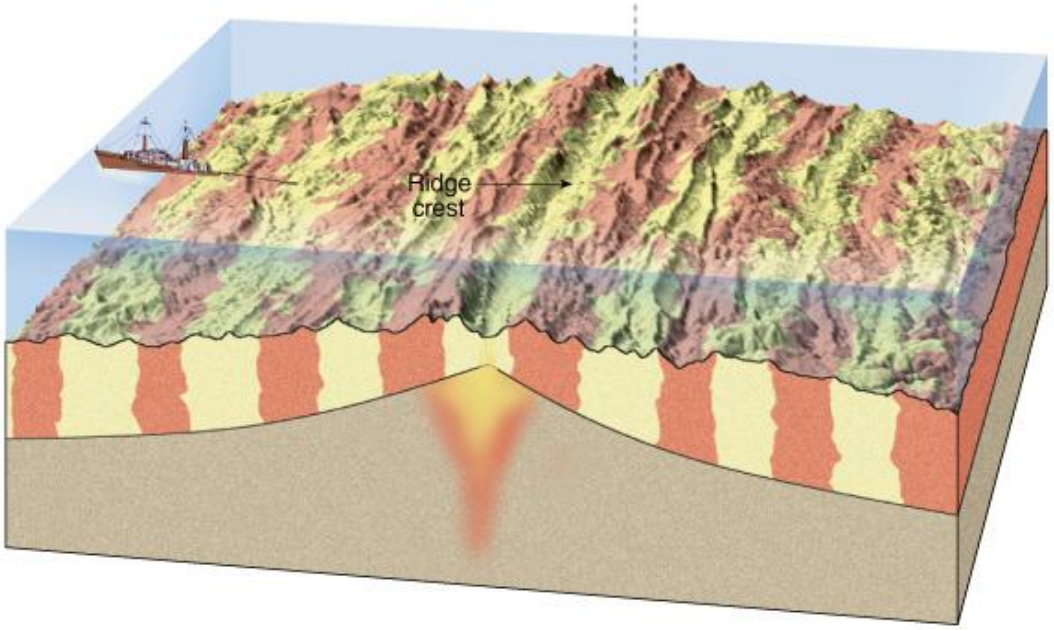
## Age of the oceanic crust



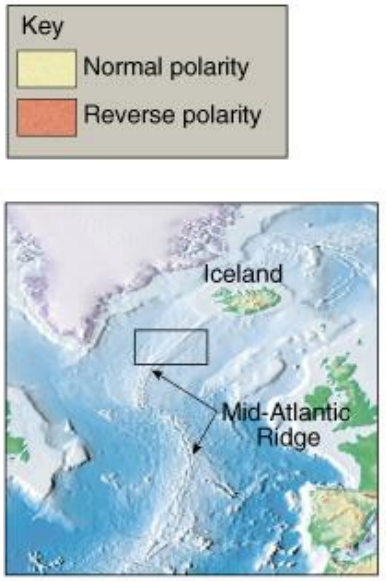

- Youngest sea floor is at mid-ocean ridge
- Oldest sea floor away from mid-ocean ridge

# Seafloor spreading

## Paleomagnetism



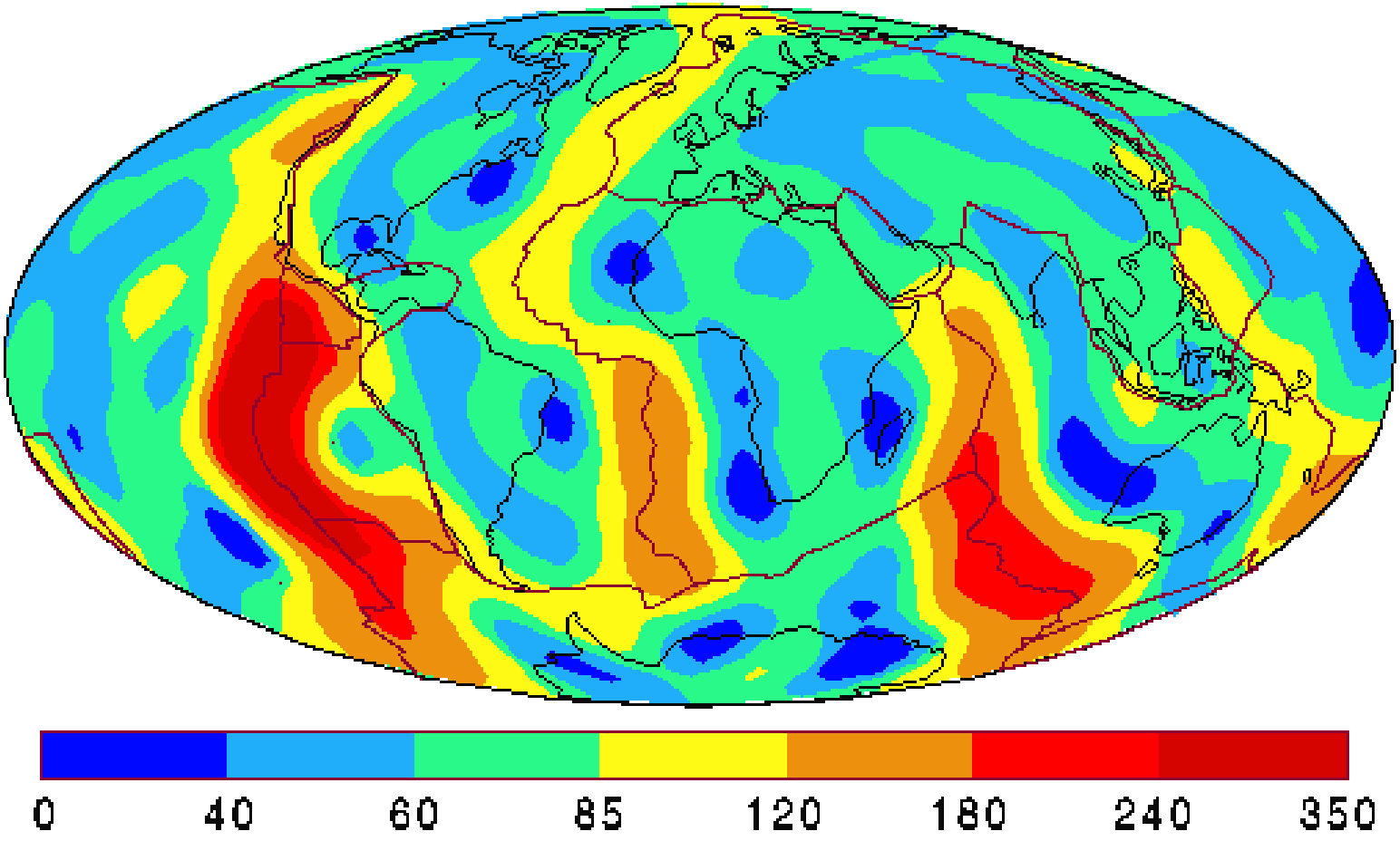

B. Research vessel towing magnetometer across ridge crest



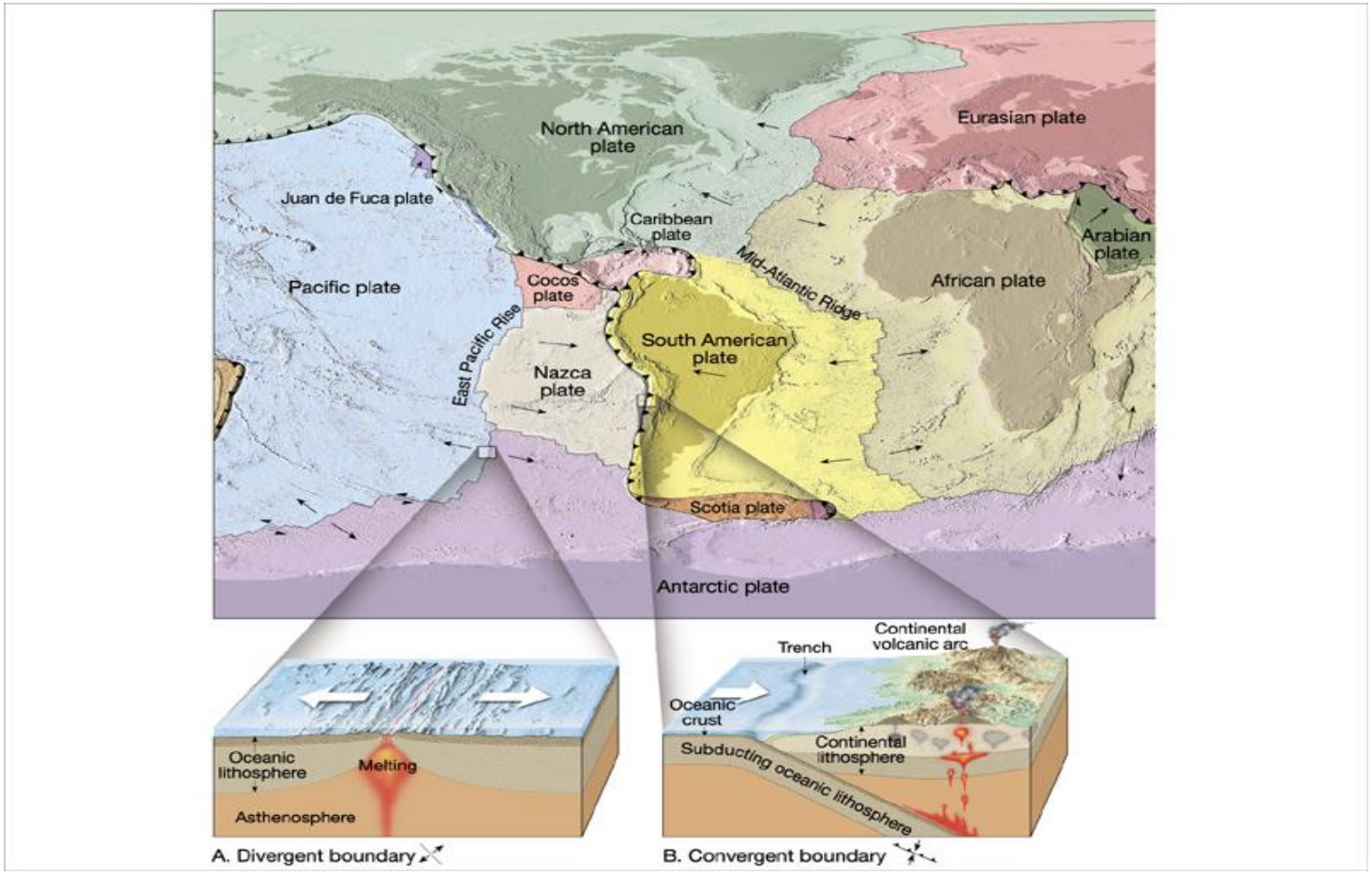

C. Location map

# Seafloor spreading

## Heat flow



# Seafloor spreading




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

# Plate tectonics

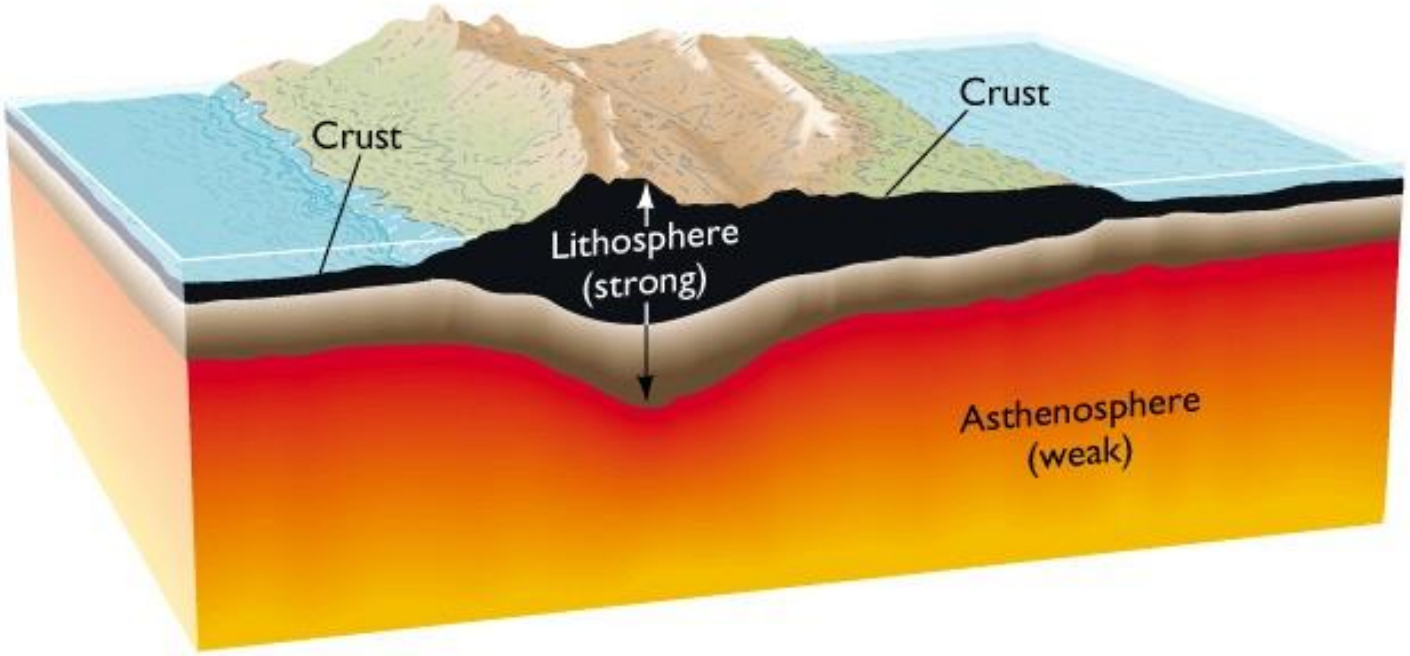
- The unifying concept of the Earth sciences.
- The outer portion of the Earth is made up of about 20 distinct “plates” (~ 100 km thick) that move relative to each other.
- Plates interact with each other along their edges (plate boundaries)
- Plate boundaries have high degree of tectonic activity
 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

# Plate tectonics

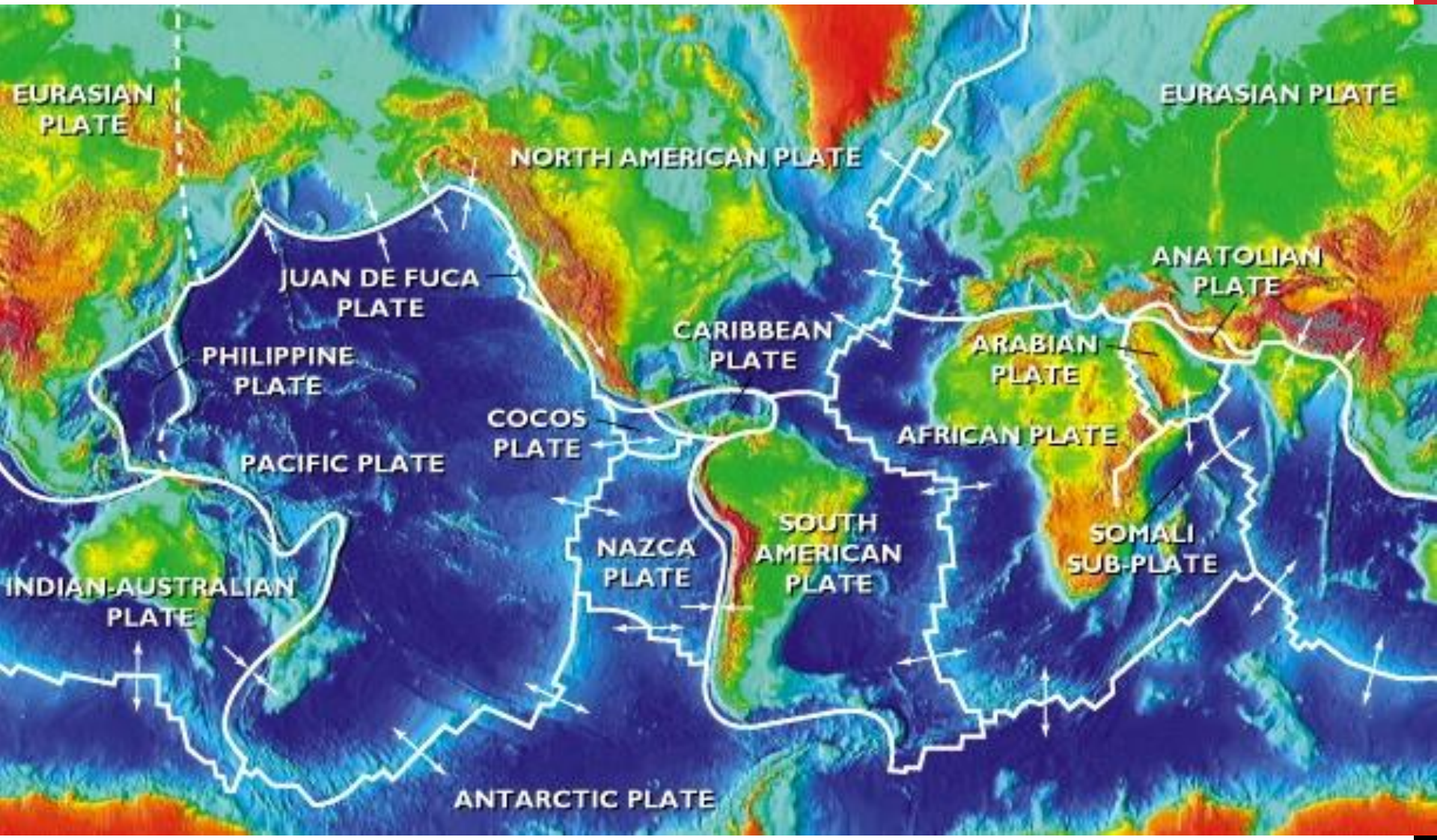
***Lithosphere*: the outer rigid shell of the earth (~ 100 km). The plates are composed of this material.**

***Asthenosphere*: part of mantle beneath lithosphere.**

**The lithosphere rides on the top of the Asthenosphere**

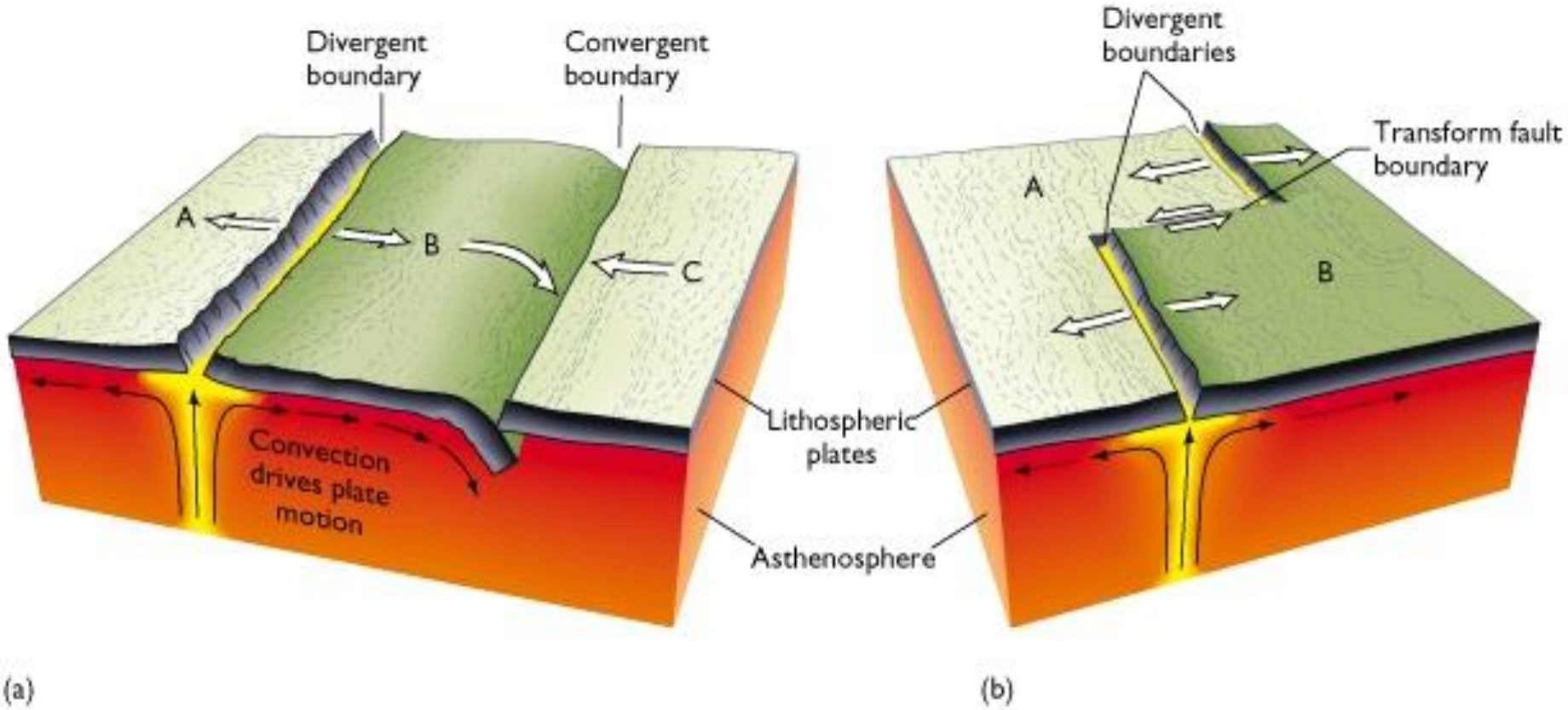


# Present day plates



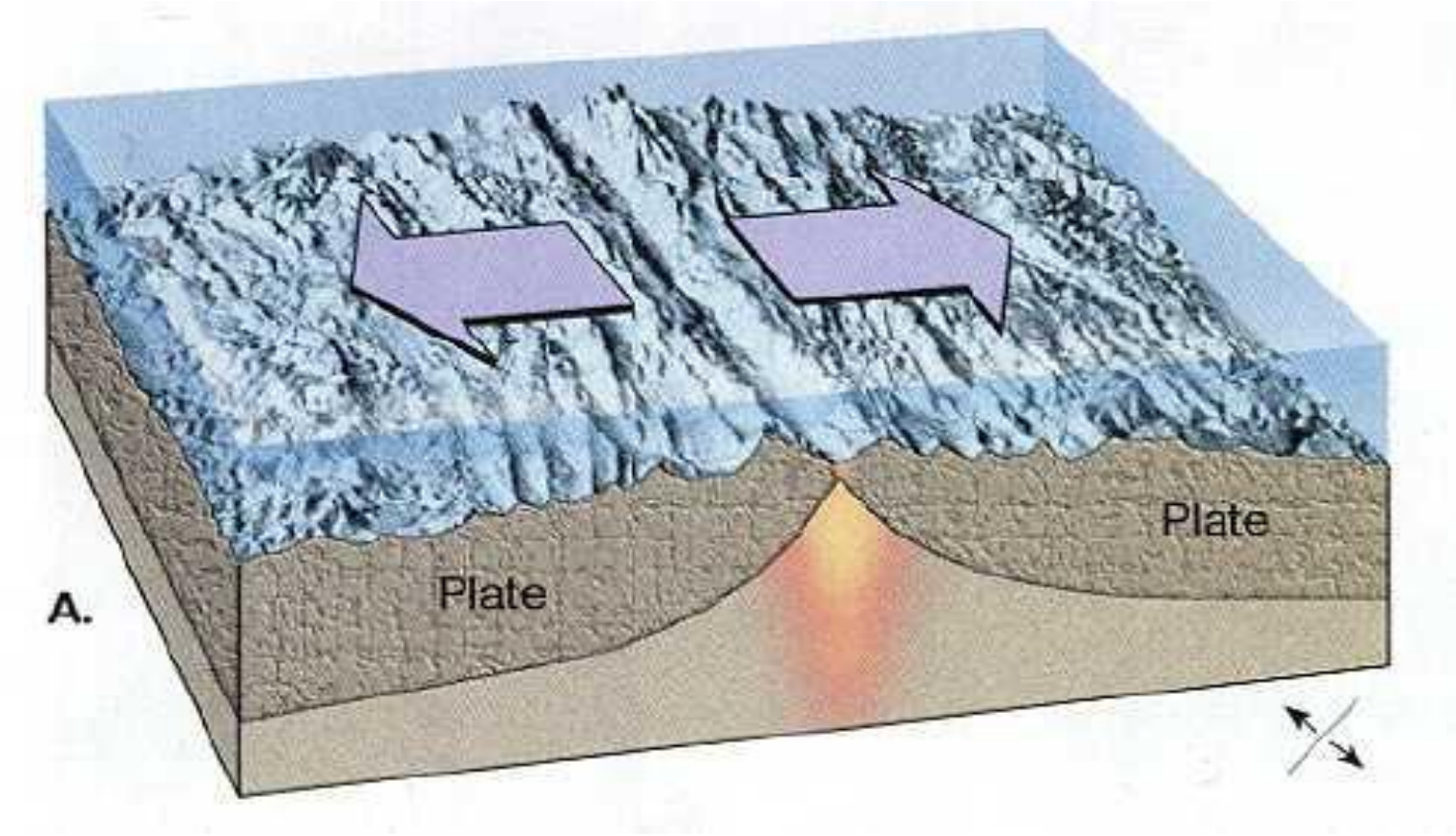
# Three types of plate boundaries

1. Divergent
2. Convergent
3. Transform/Conservative



# Plate Boundaries

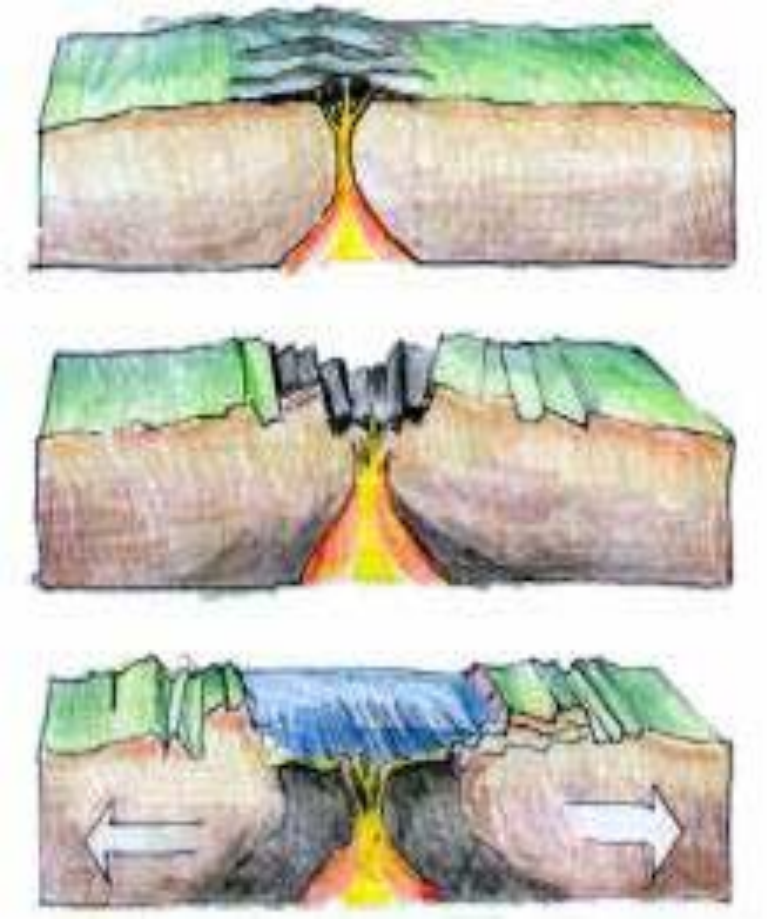
## Divergent



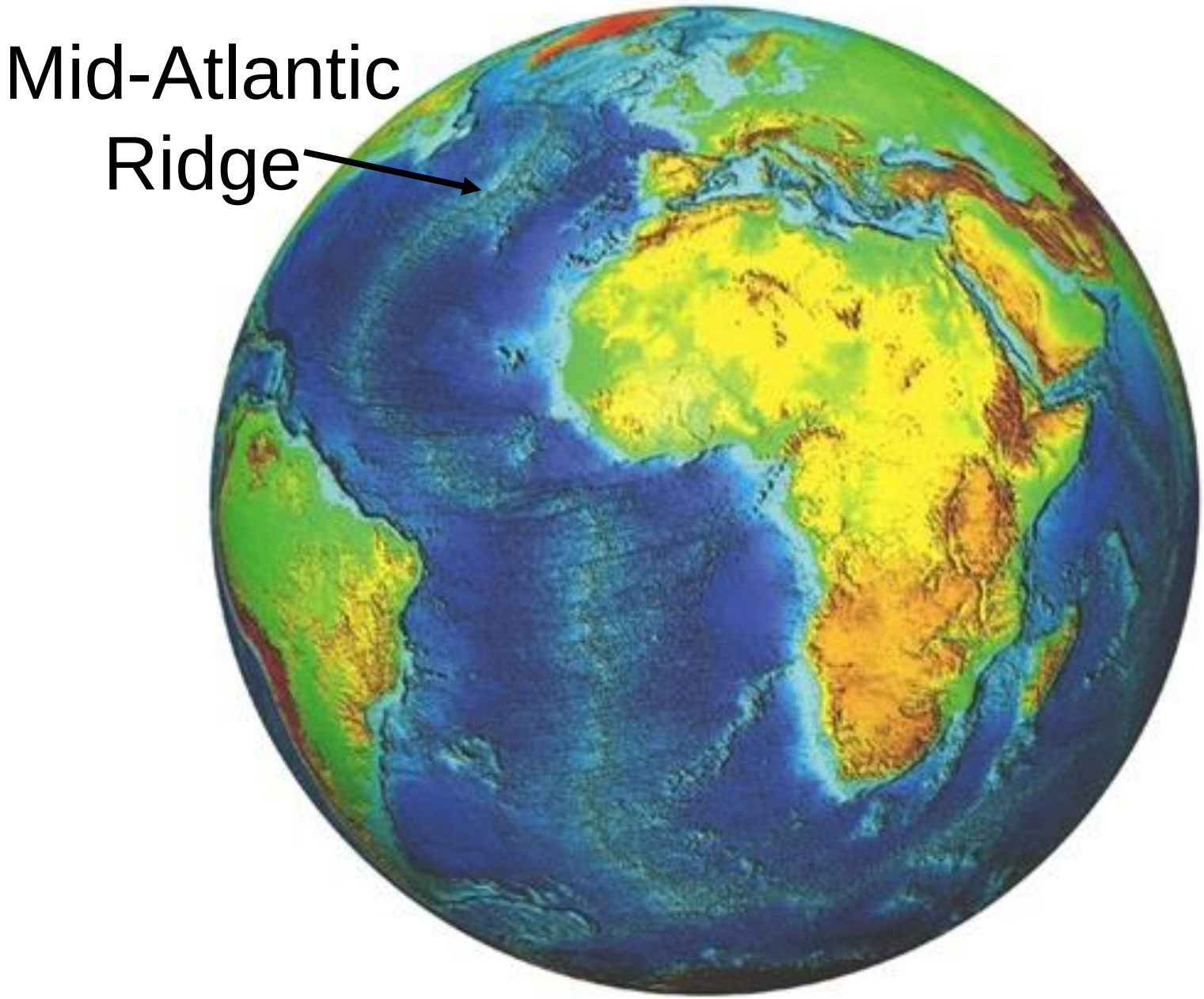

**Plates move away from each other**

**New crust is being formed**

# Divergent Boundaries



- Youngest rocks form at ridge
- Older rocks are further from ridge

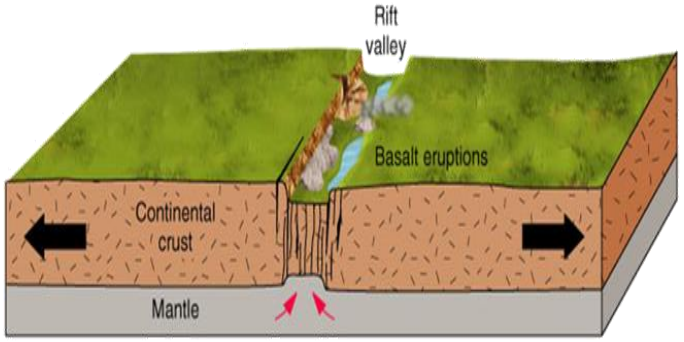



Peter W. Sloss, NOAA-NESDIS-NGDC

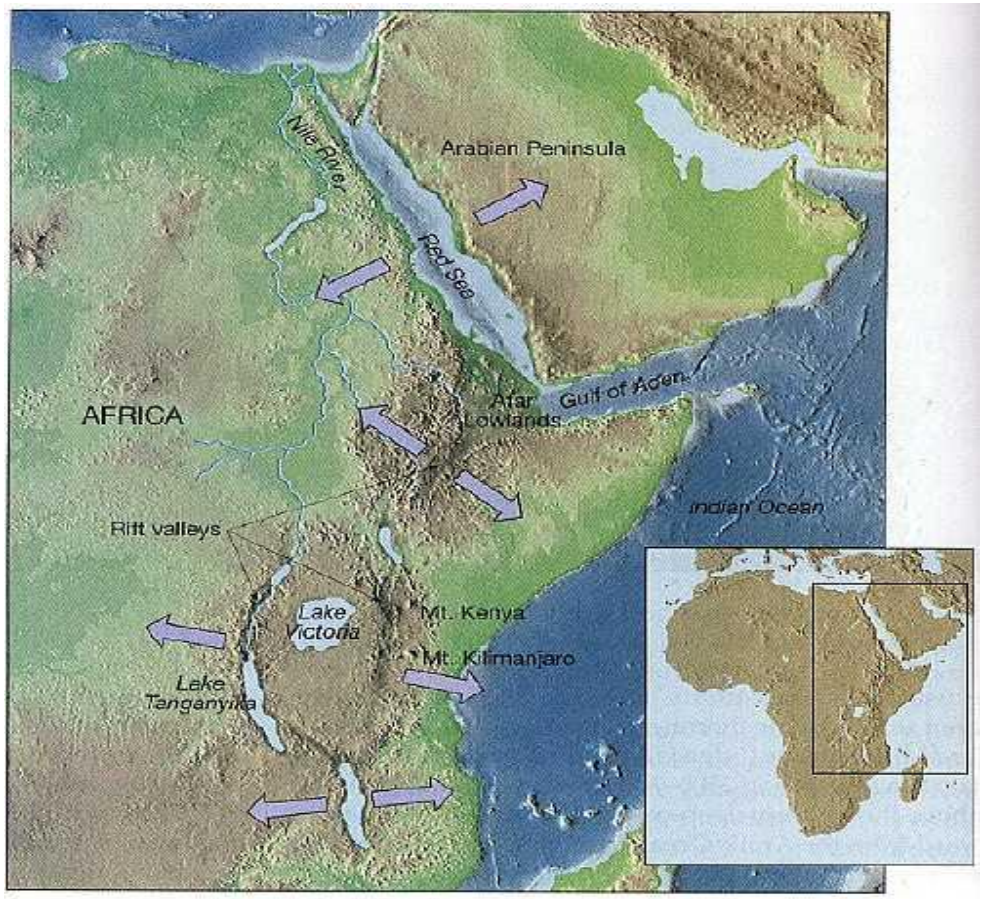
# Divergent Boundaries

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

Gudmundur E. Sigvaldason,
Nordic Volcanological Institute

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

Fig. 1.15

# Convergent Boundaries

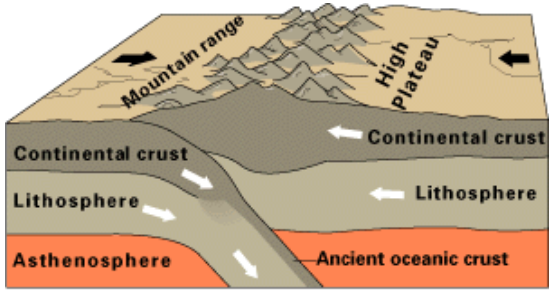
- Plates are moving toward each other

- Crust is being destroyed

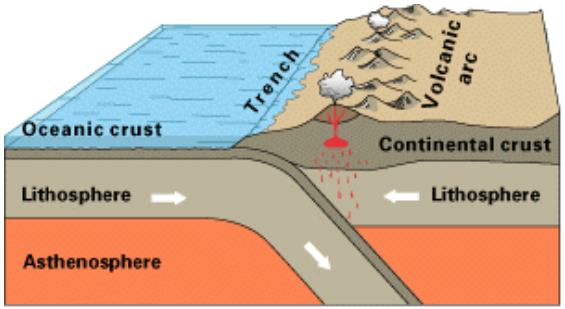
- Three Types:
  - Ocean-continent
  - Ocean-ocean
  - Continent-continent

# Convergent Boundaries

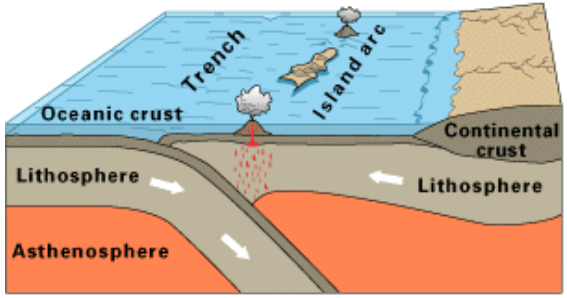
- Destroys old crust and forms new mountains
- Three types of convergent boundaries



Continental-continental convergence



Oceanic-continental convergence

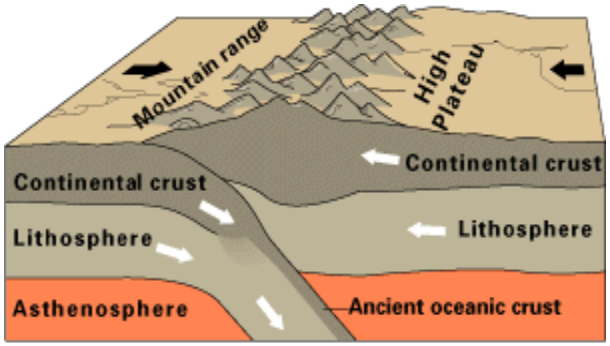


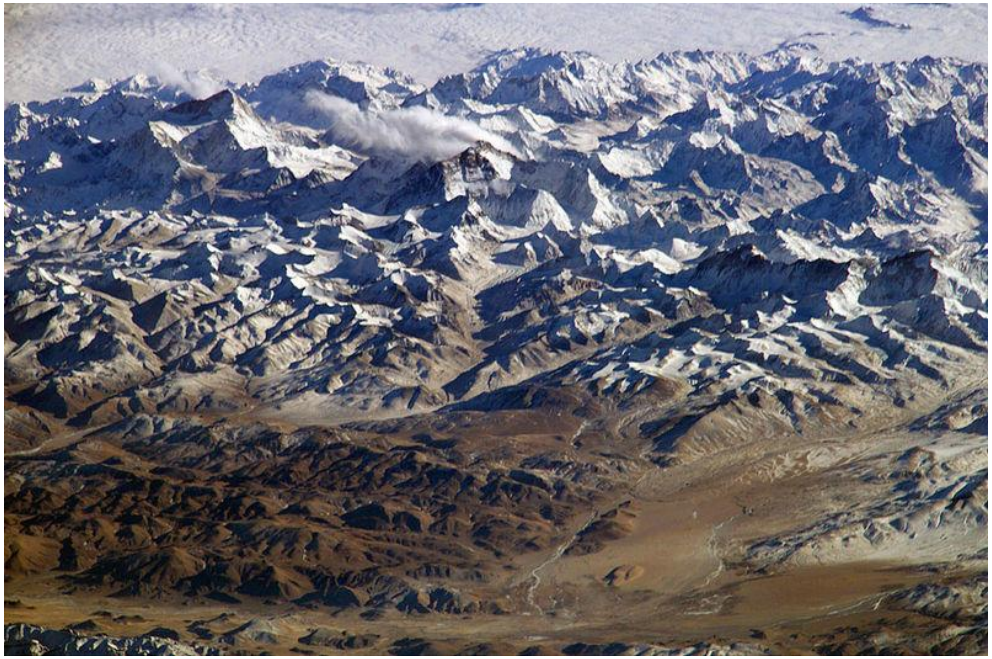
Oceanic-oceanic convergence

# 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****..*

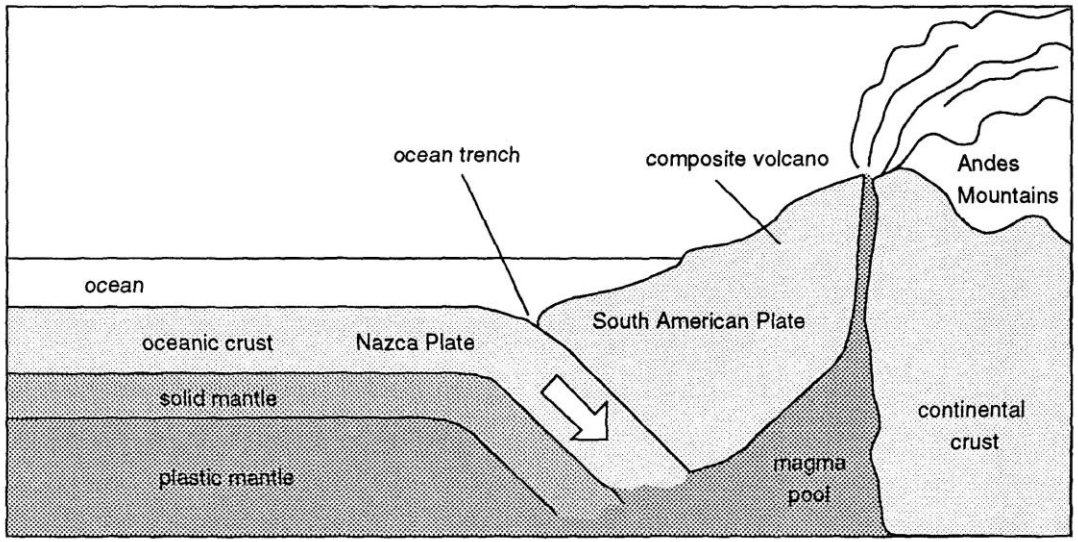


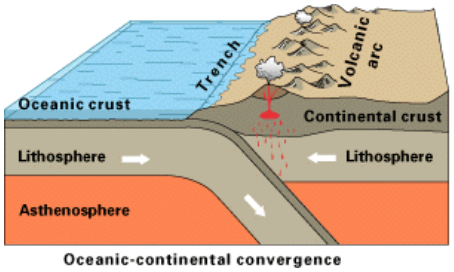

**Fig. 8–3.** Subduction of the Nazca Plate below the South American Plate forming composite volcanoes

*Denser oceanic plates always subduct beneath less dense continental plates*

# Convergent Boundaries

Ocean-continent convergence

Trench &  Coastal Volcanoes



Oceanic-continental convergence

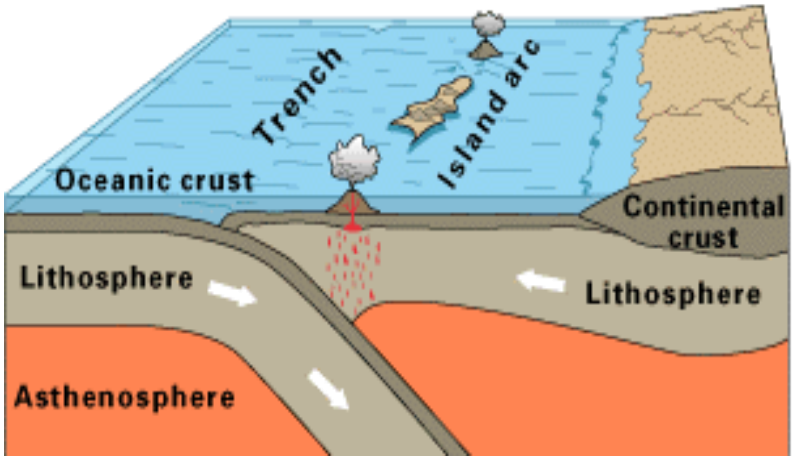
# Convergent Boundaries

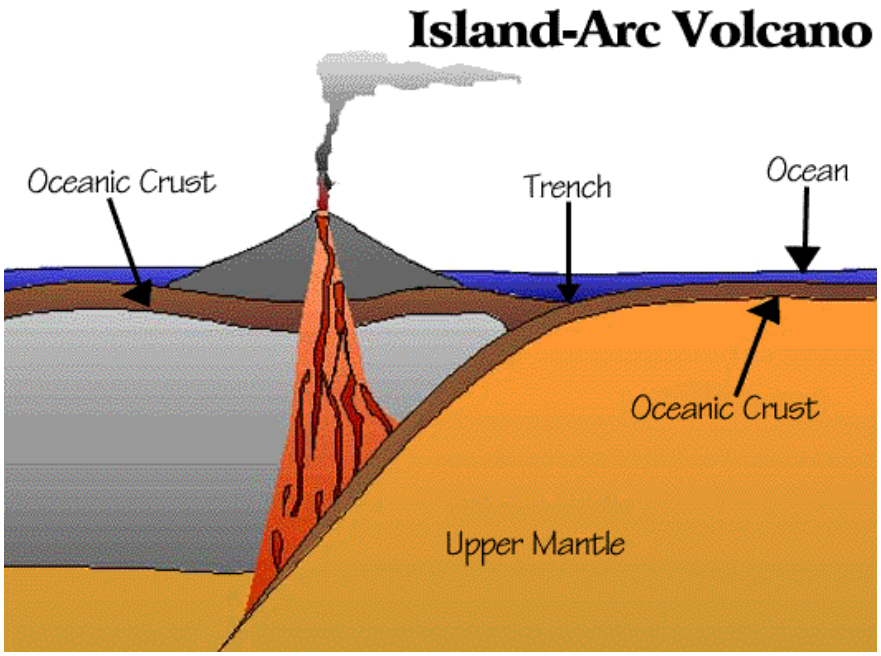
Ocean-continent convergence

# Convergent Boundaries

Ocean-ocean convergence

Trench & Island arc

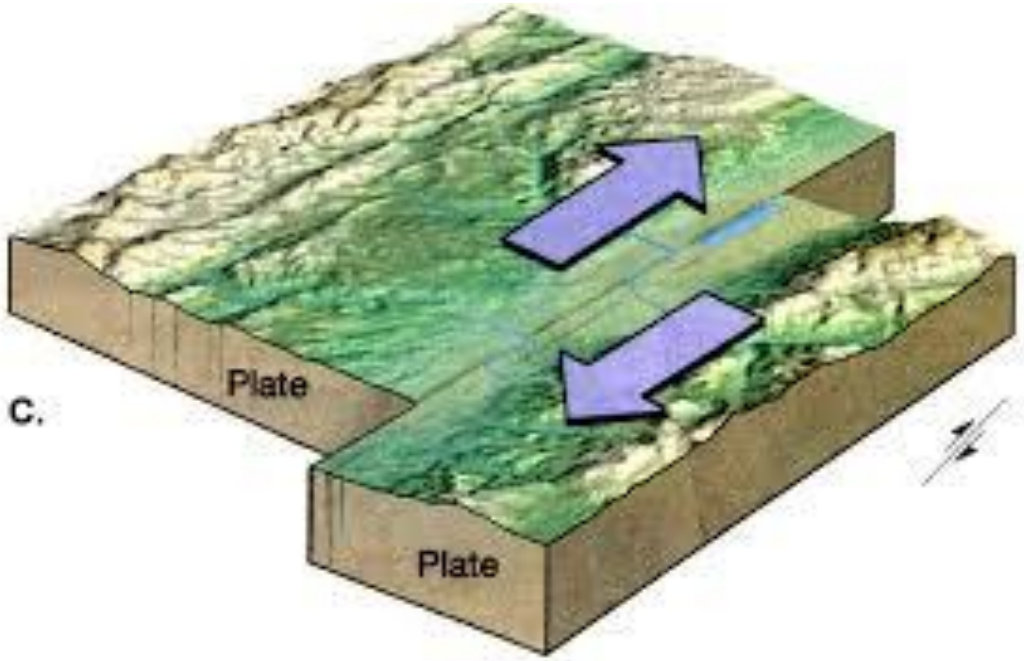


# Transform plate boundary

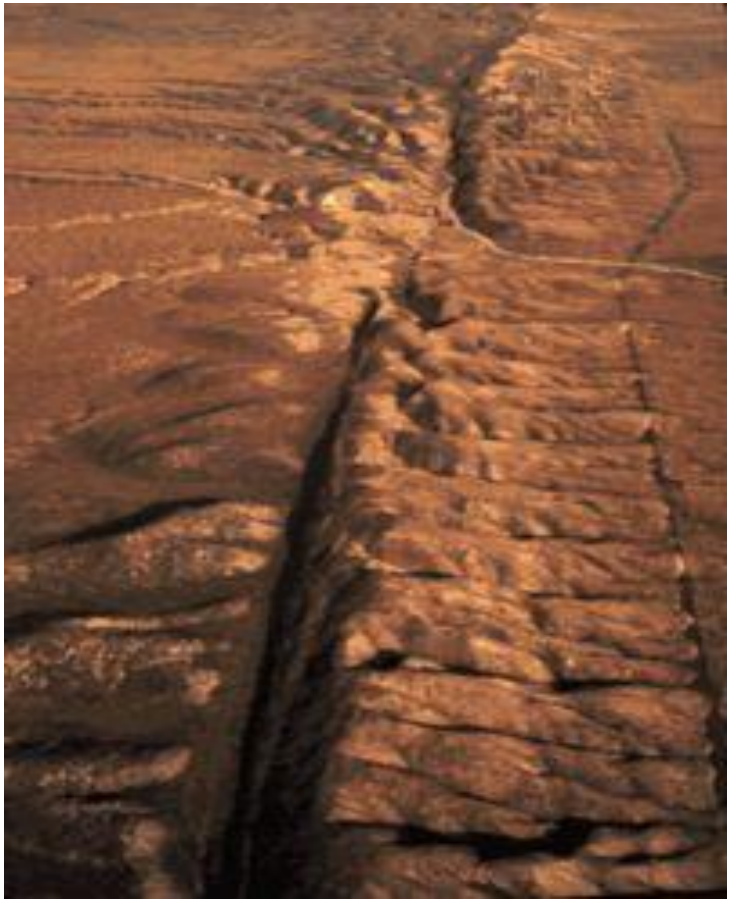
- Crust is neither created nor destroyed

**Plates slide past one another**



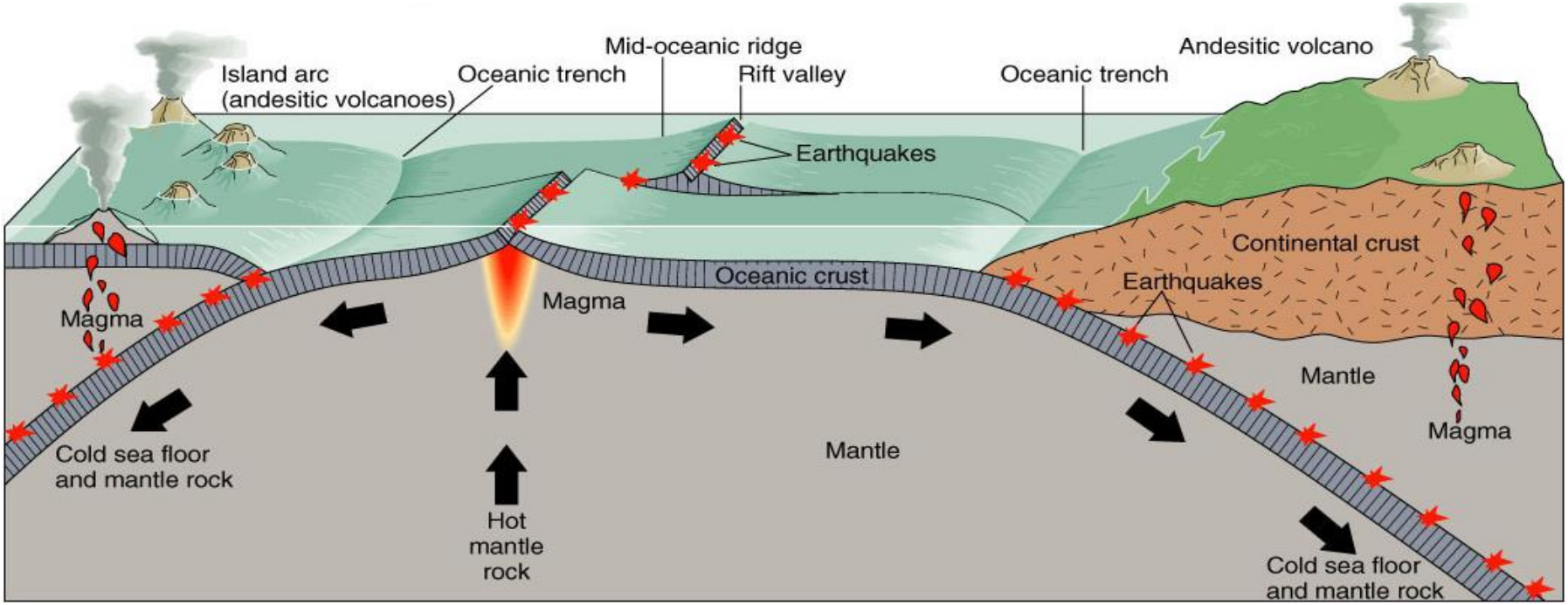
# Transform plate boundary


San Andreas Fault



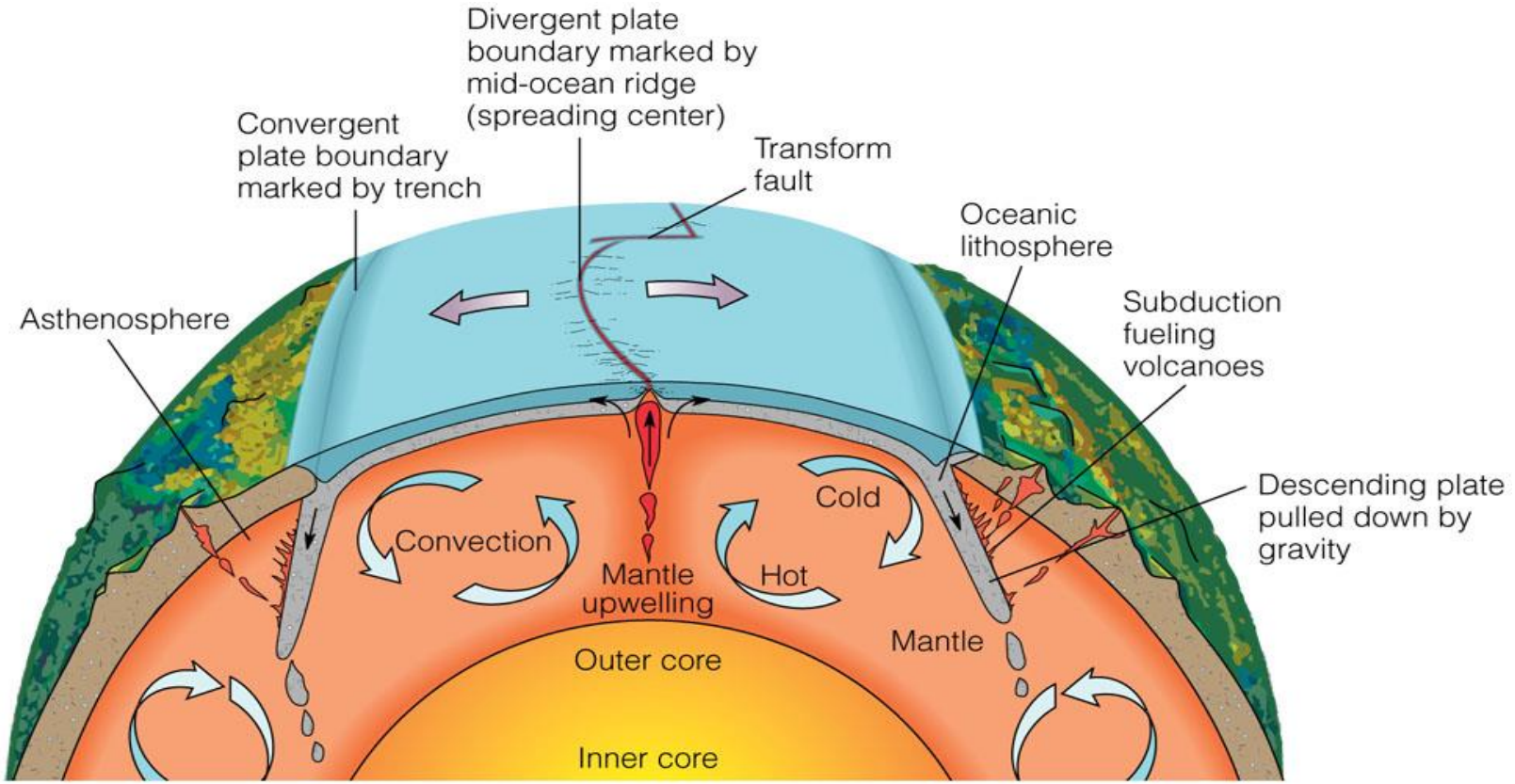
**Carrizo Plains, Central California**

# Summary of Plate Movements



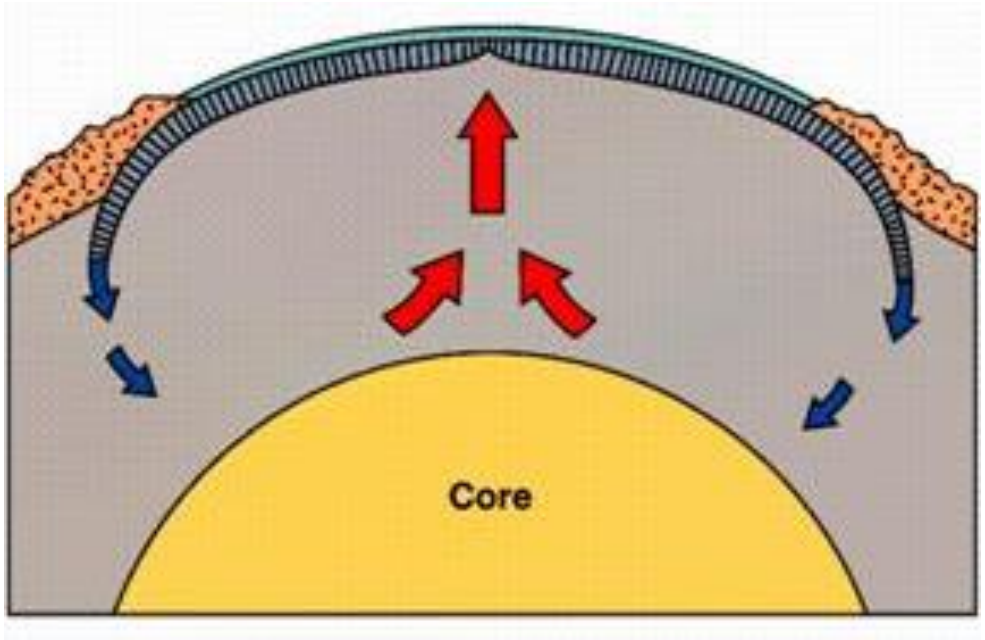
# Convection currents

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



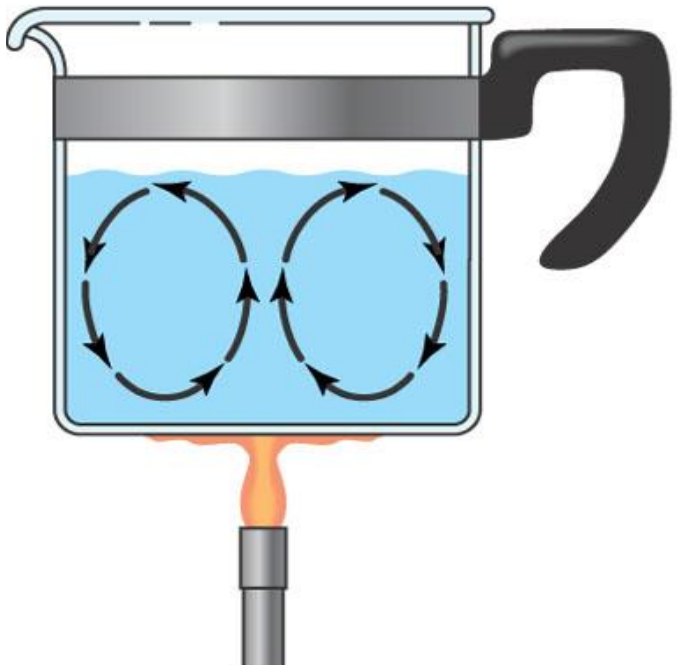
# Convection currents

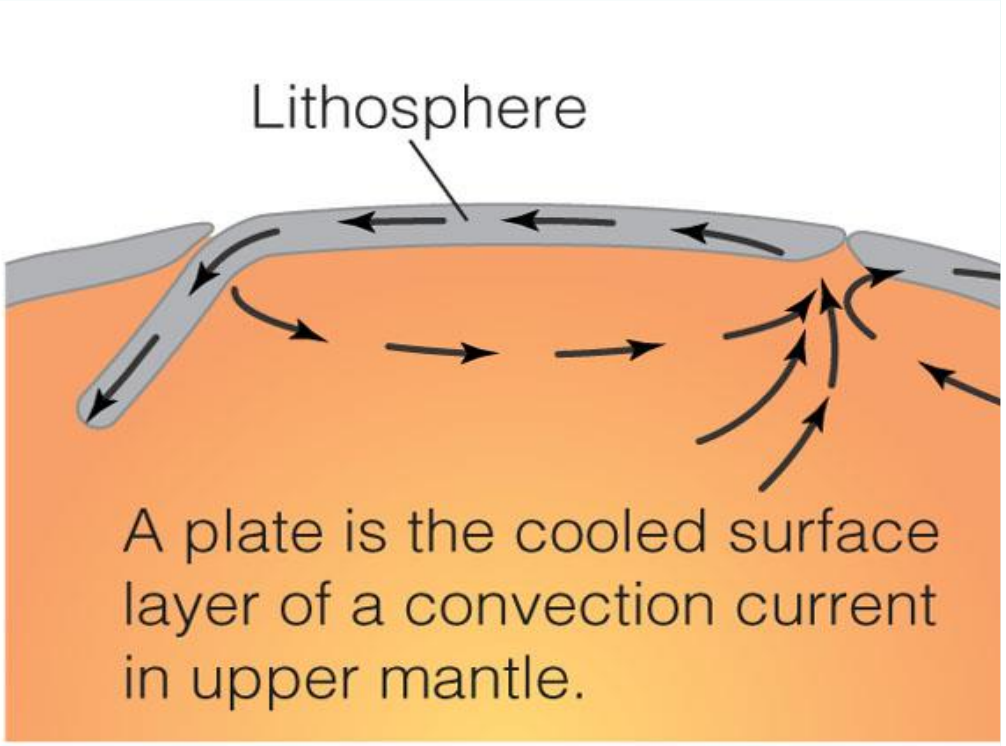
Driving force for convection?




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

# Convection currents





# How deep does the convection occurs?

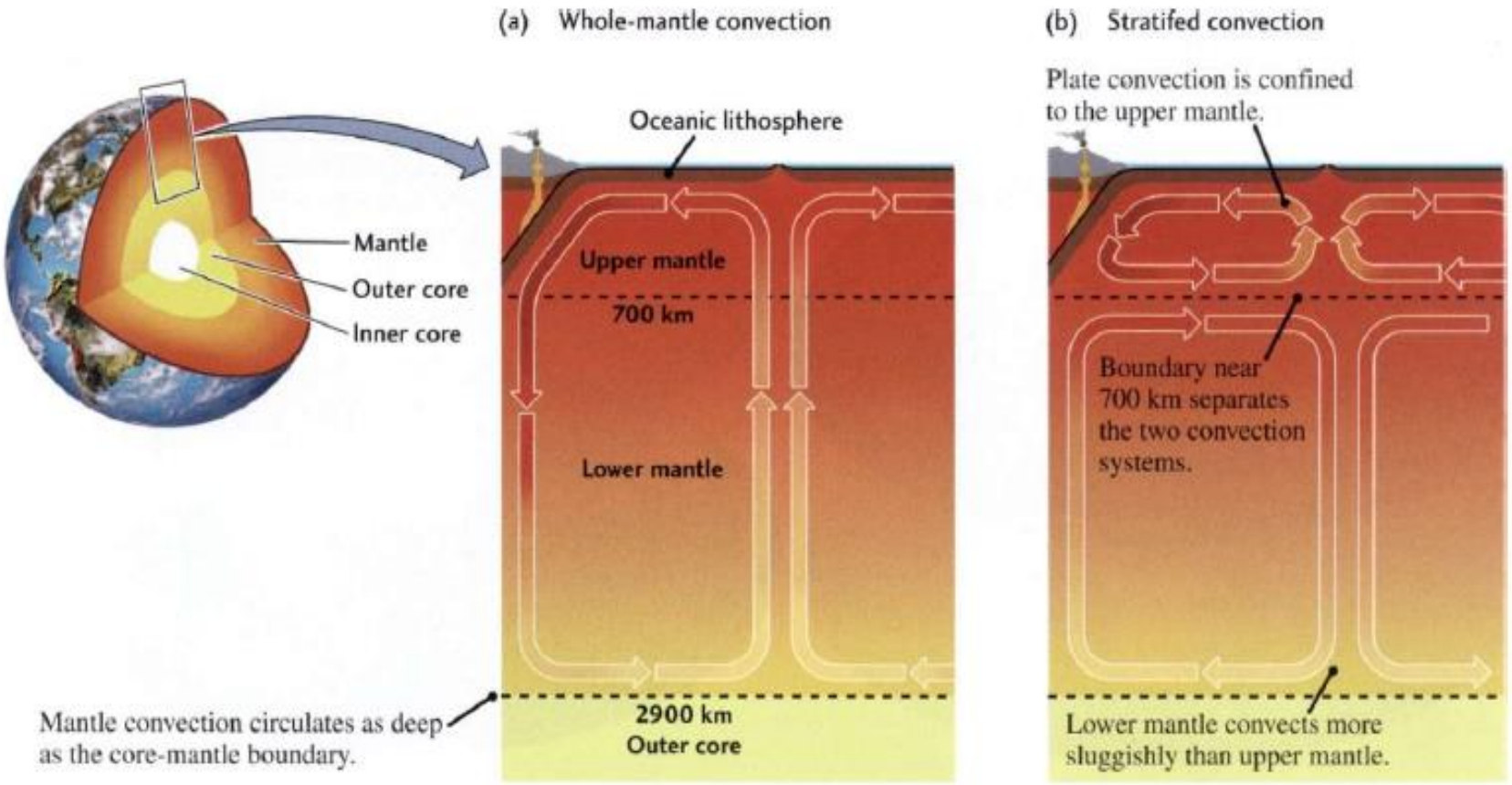



Figure 2.14 Two competing hypotheses for the mantle convection system.

**Two competing hypotheses for the mantle convection system**

# Rates and History of plate movements

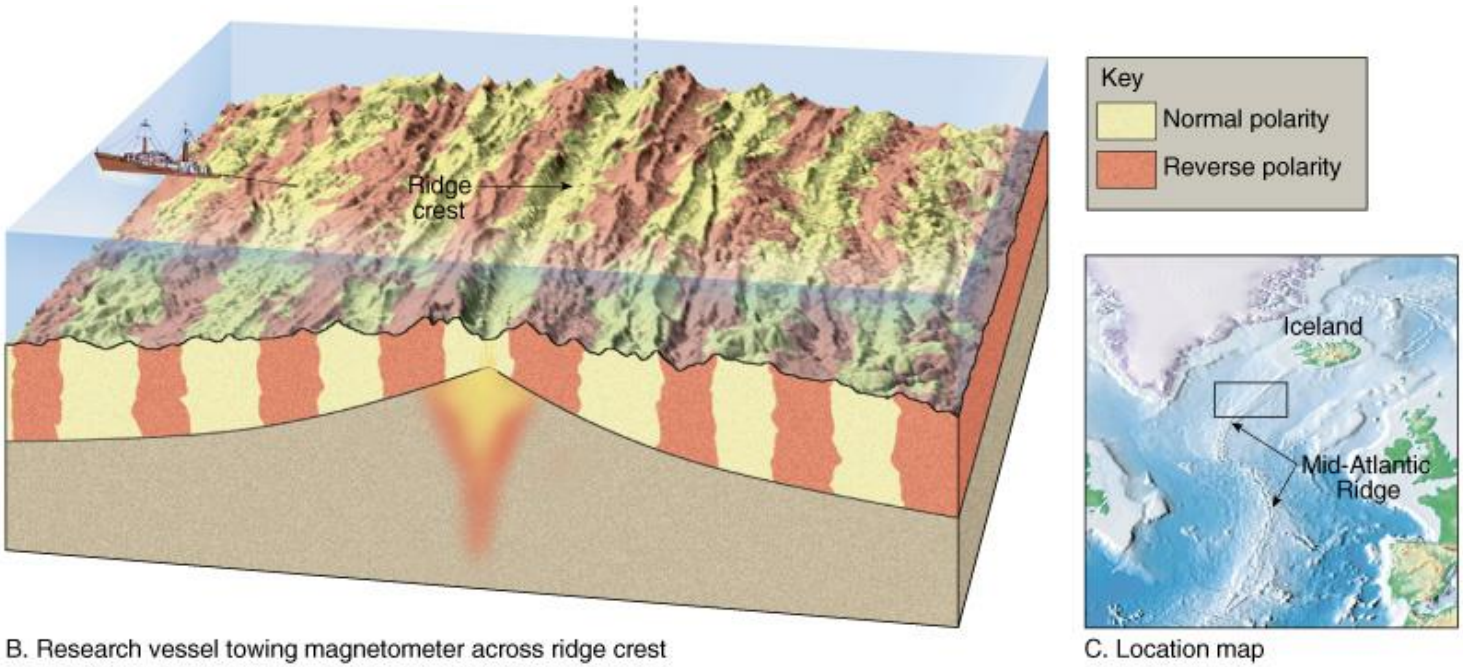
How fast do plates move?

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

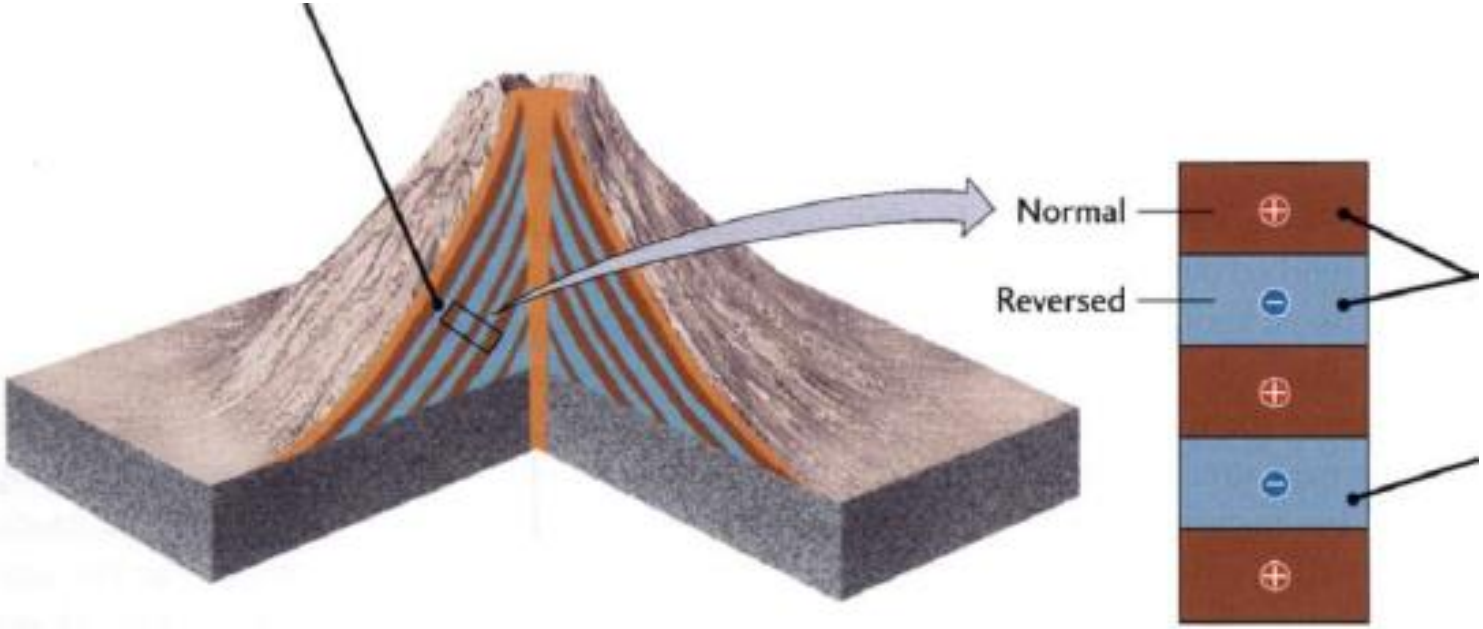
## Paleomagnetism



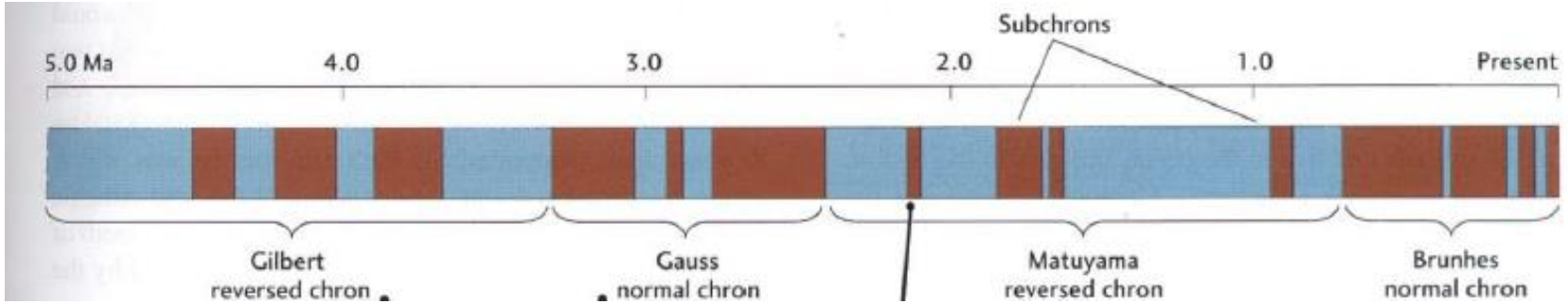

B. Research vessel towing magnetometer across ridge crest

C. Location map

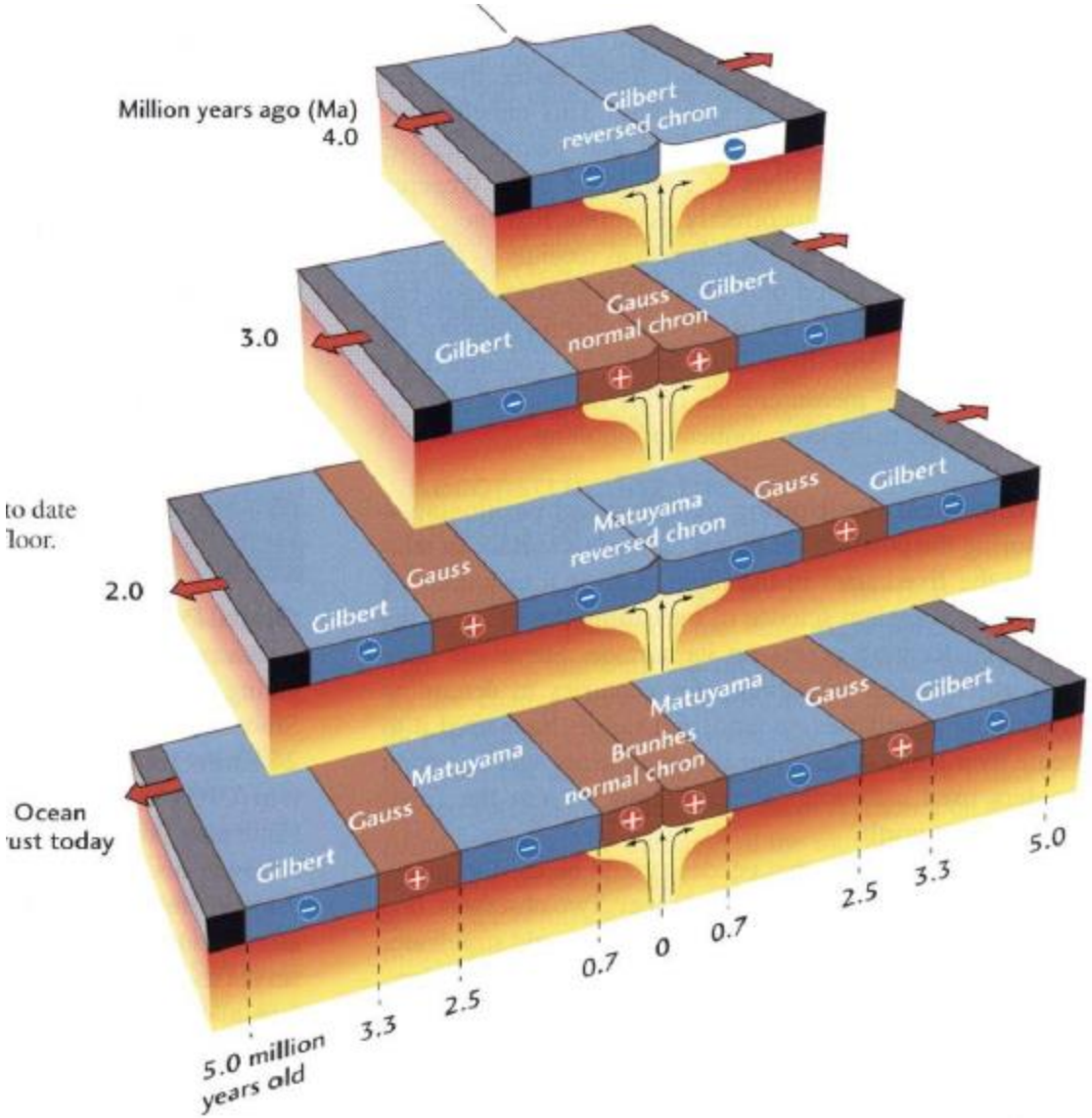
# Paleomagnetism



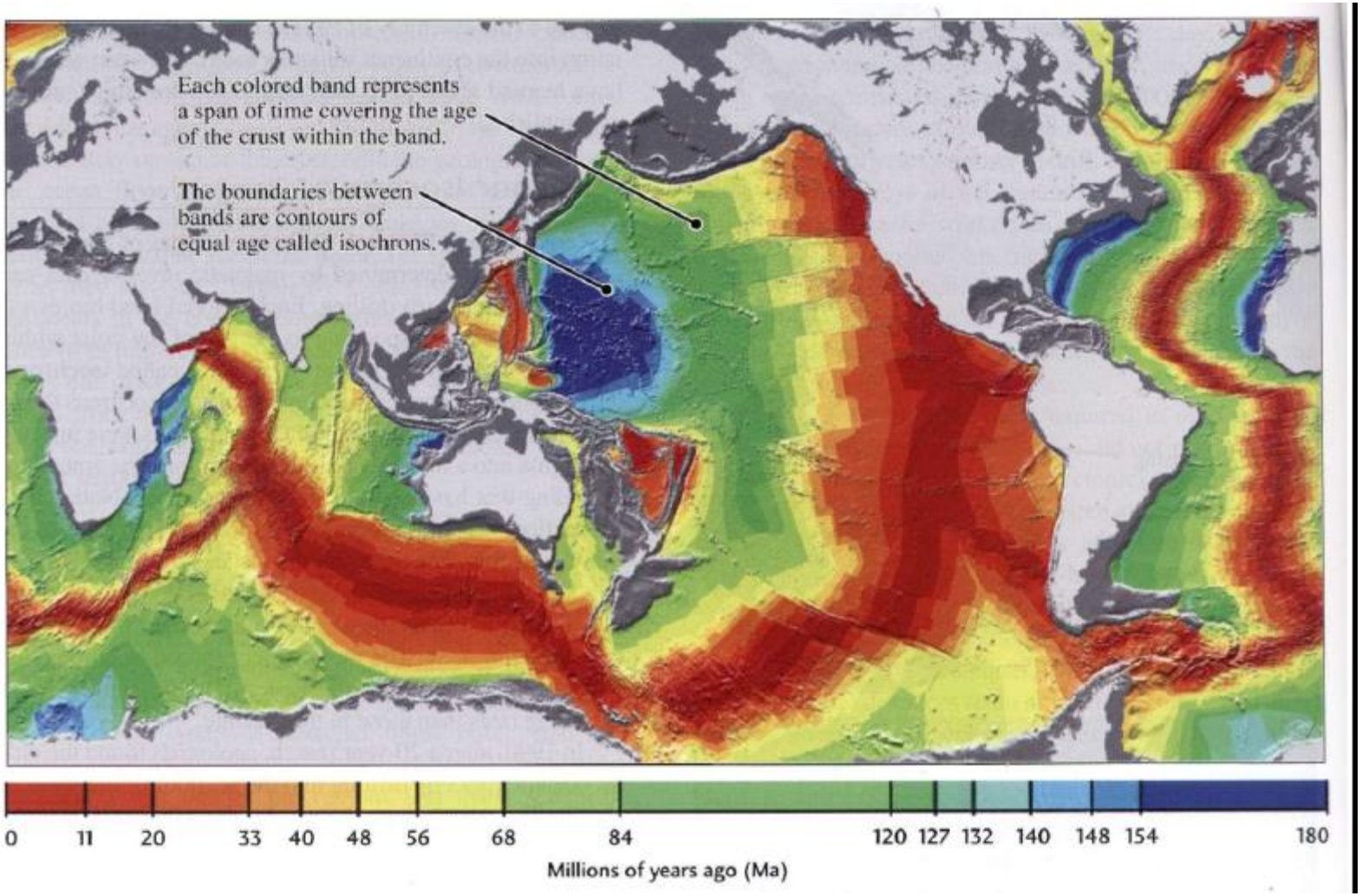
# Paleomagnetism



# Paleomagnetism



# The global isochron map of the ocean floor



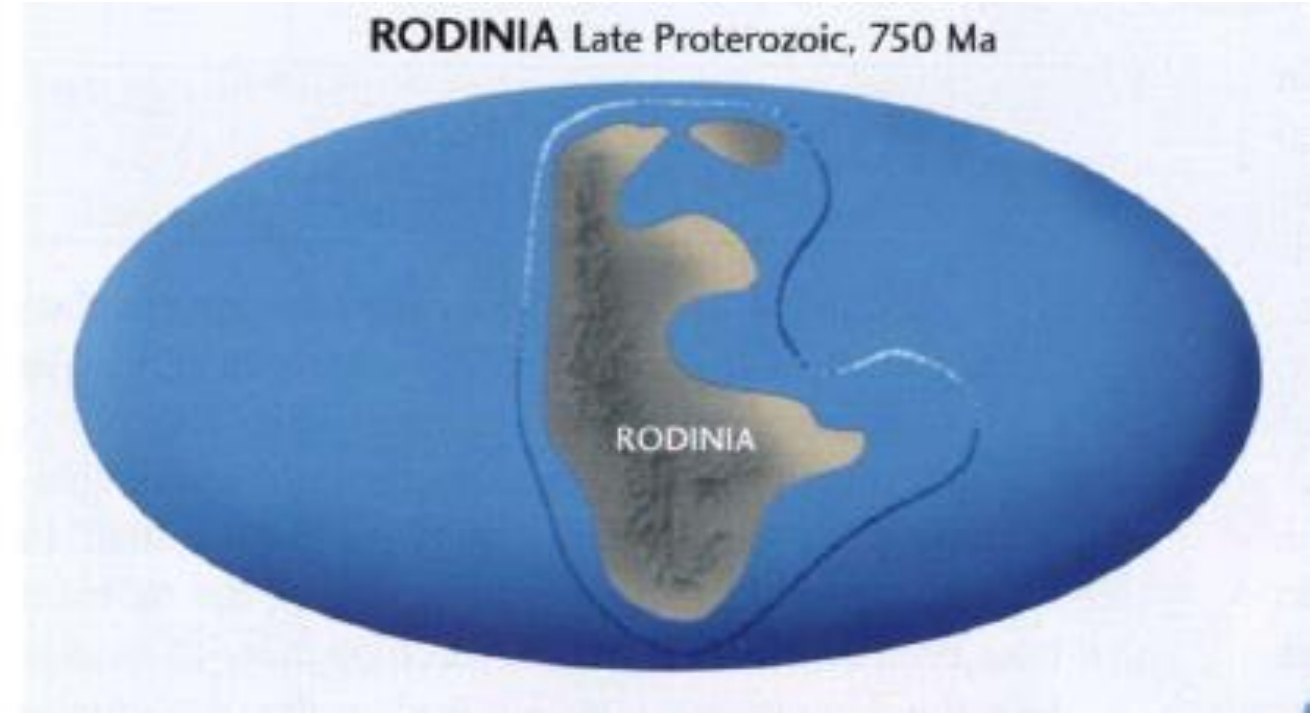
# Reconstructing history of plate movements

-Sea floor isochron

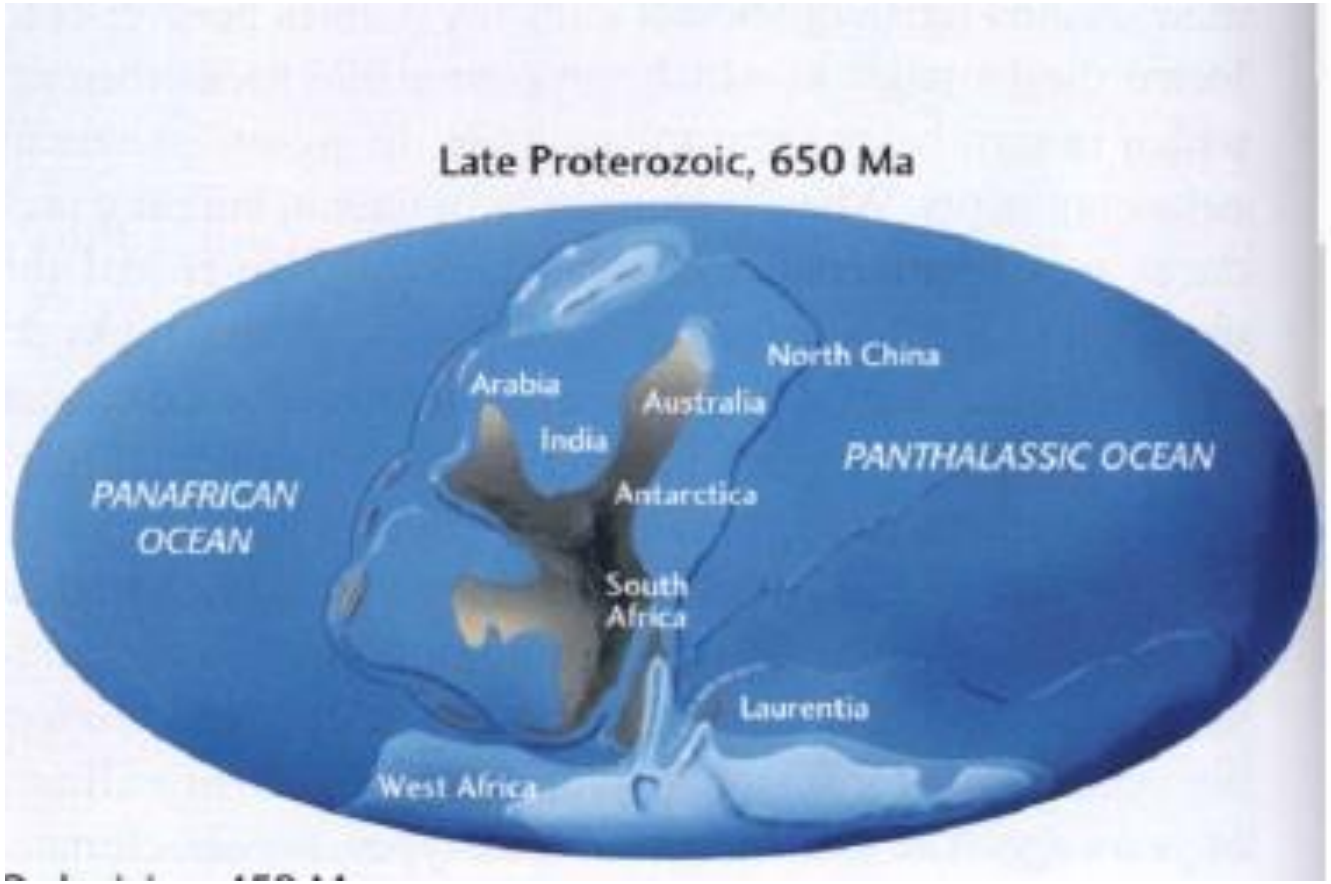
-Transform fault boundaries

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

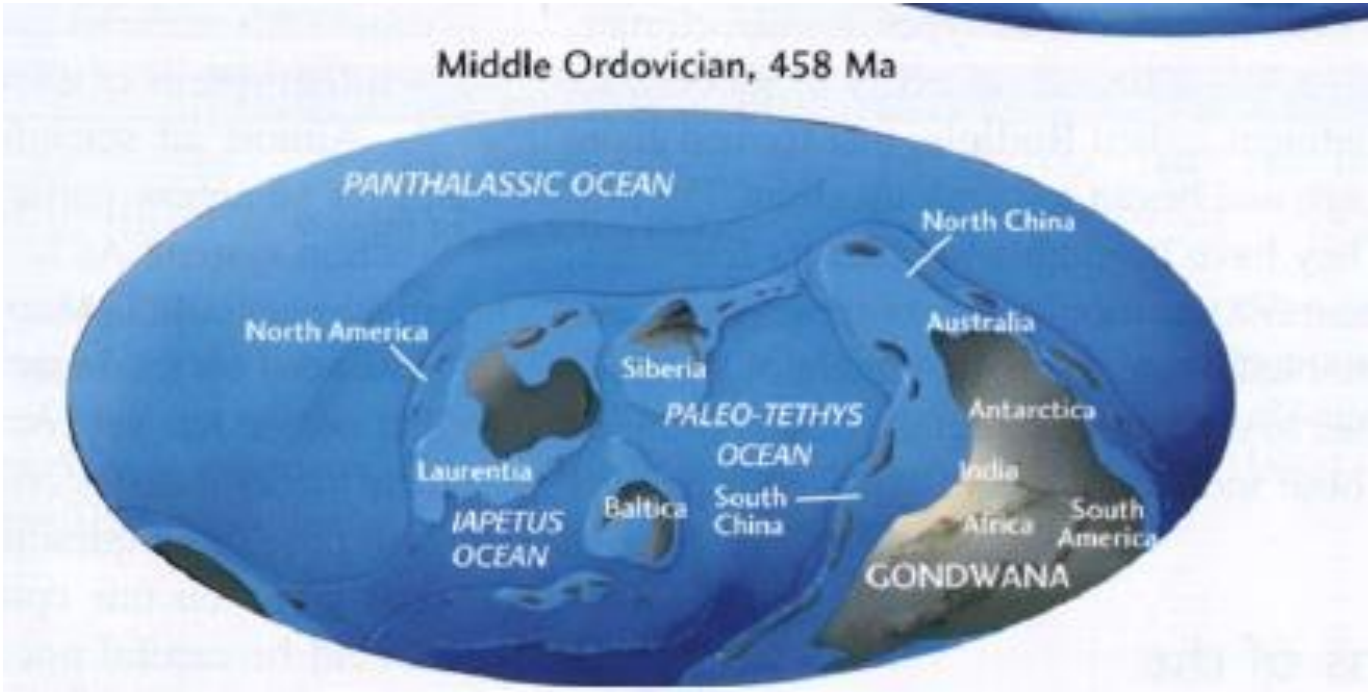
# Assembly of Pangaea



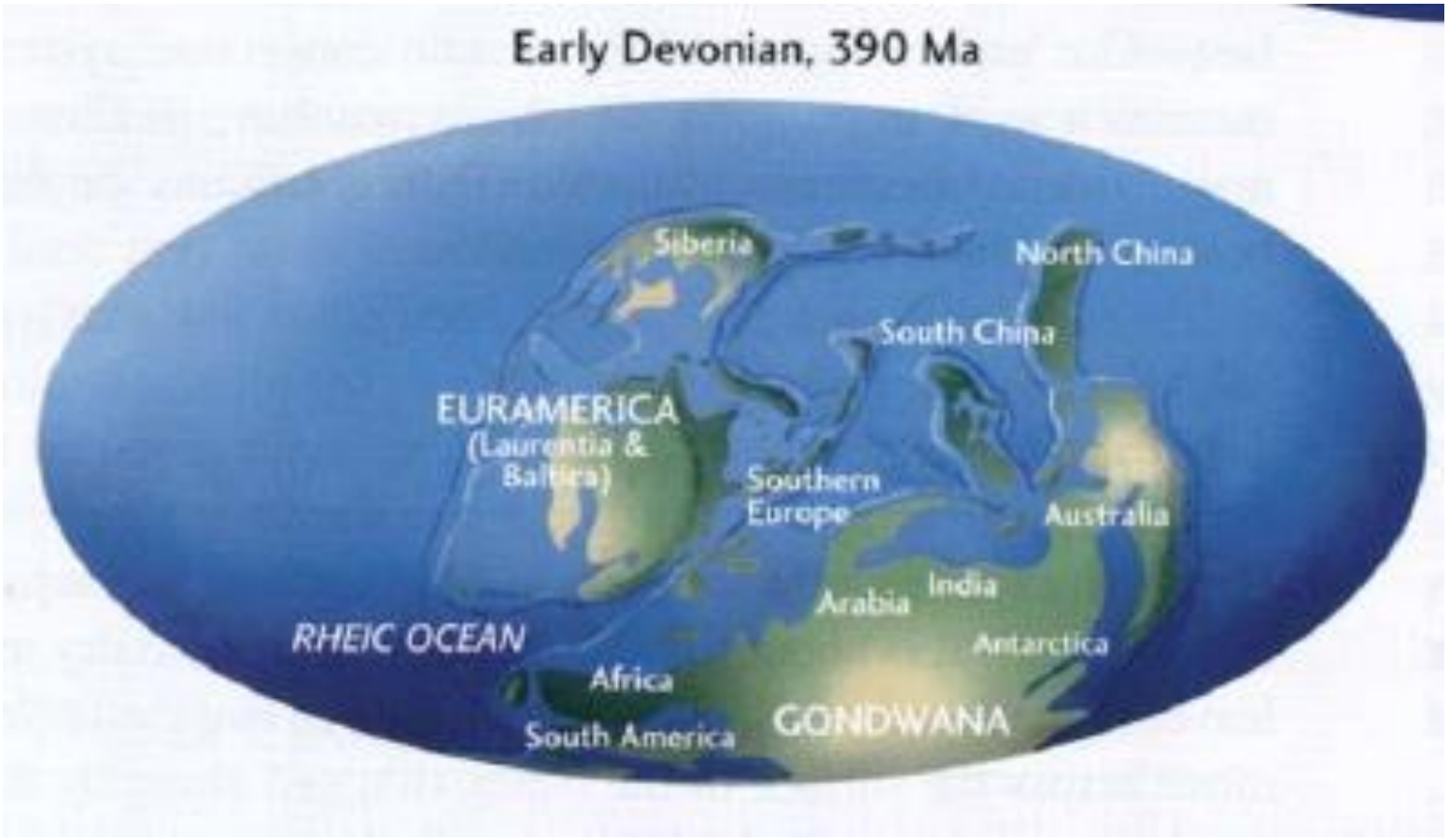
# Assembly of Pangaea



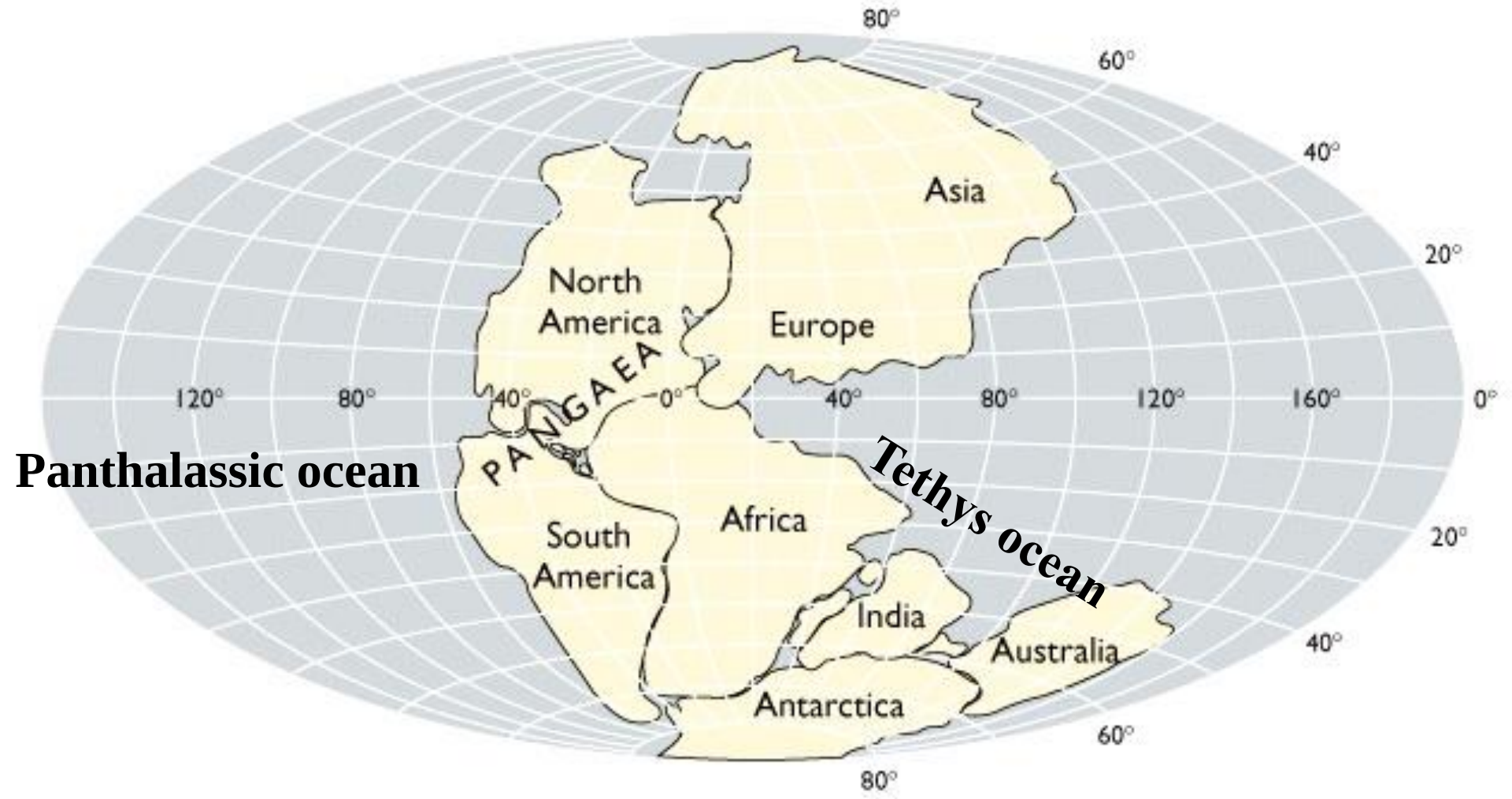
# Assembly of Pangaea



# Assembly of Pangaea

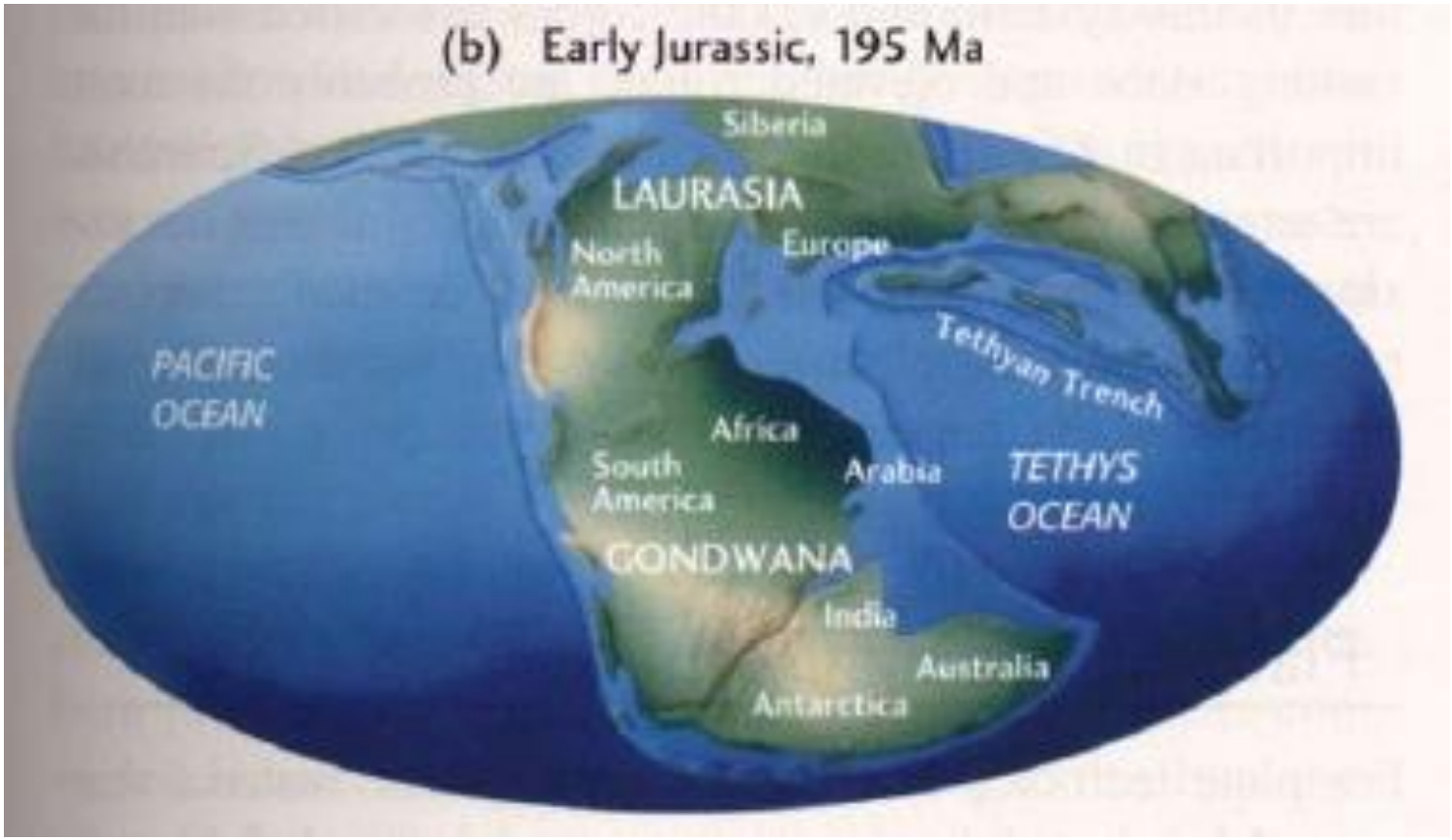


# THE SUPERCONTINENT OF PANGAEA (237 MILLION YEARS AGO)



# Break up of Pangaea

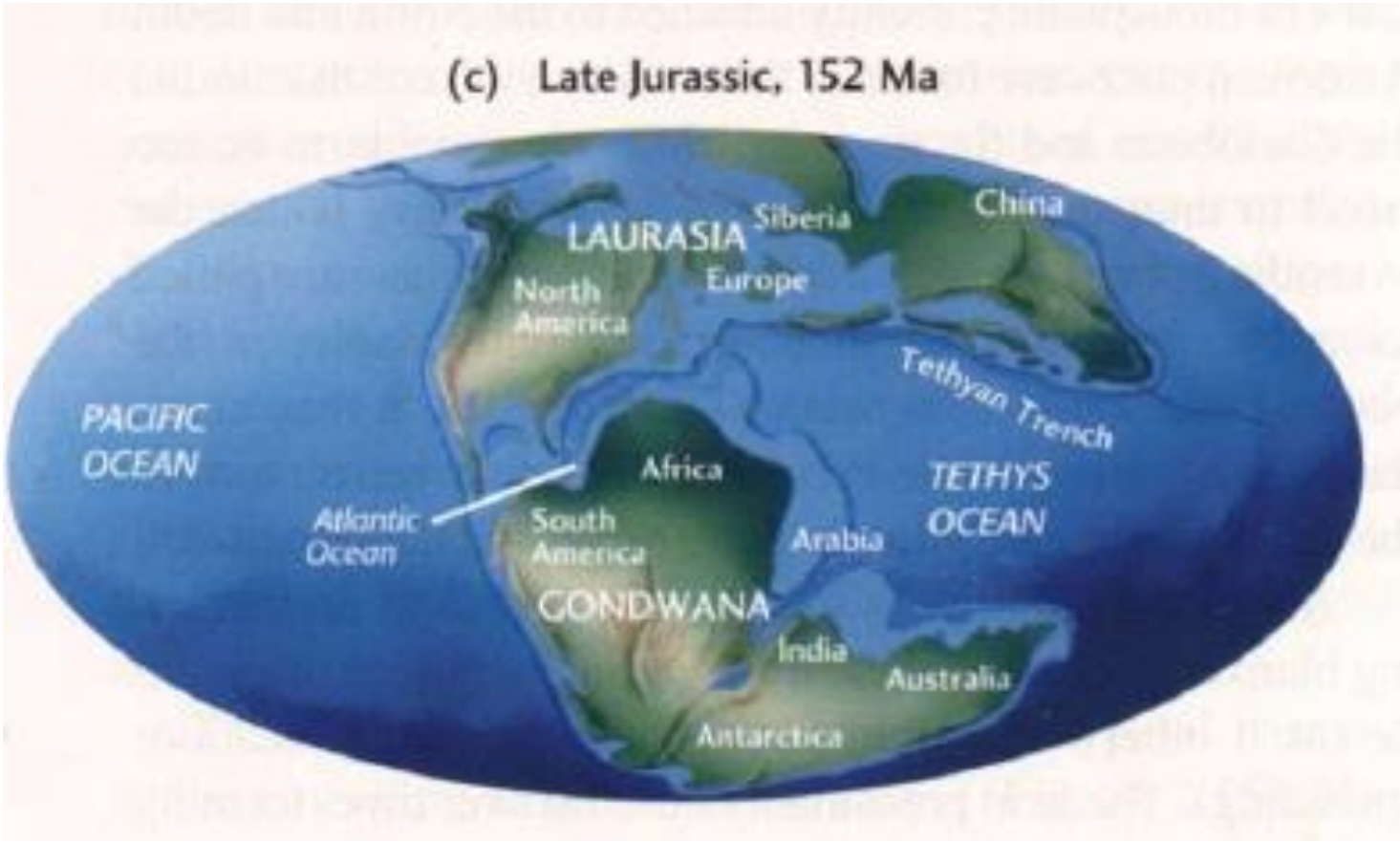
**Evidence-rift system**-volcanic rocks from Nova Scotia and North Carolina



# Break up of Pangaea

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

-Southern continents and northern continent split up

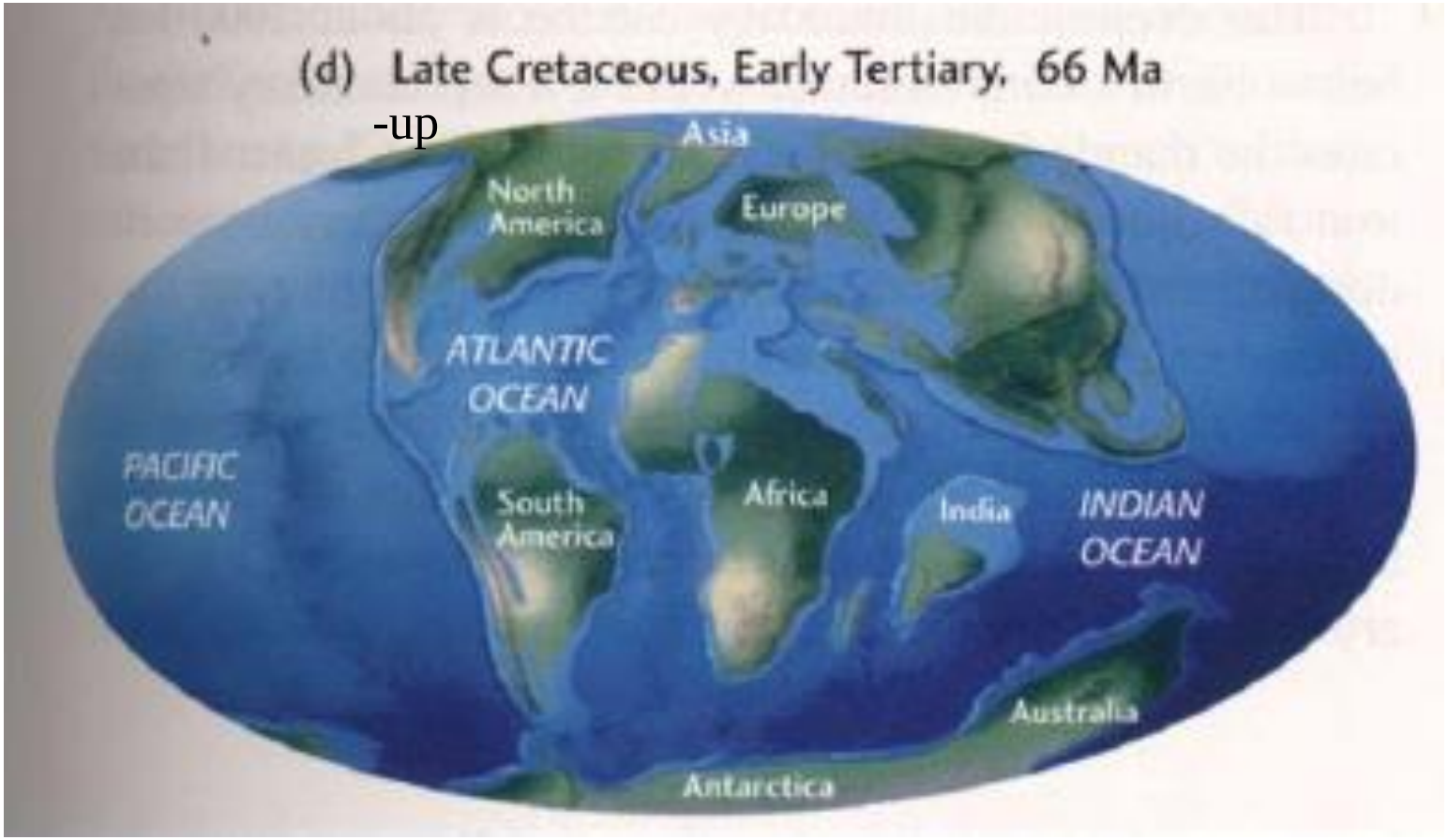


# Break up of Pangaea

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