IDC 203: INTRODUCTION TO EARTH SCIENCES

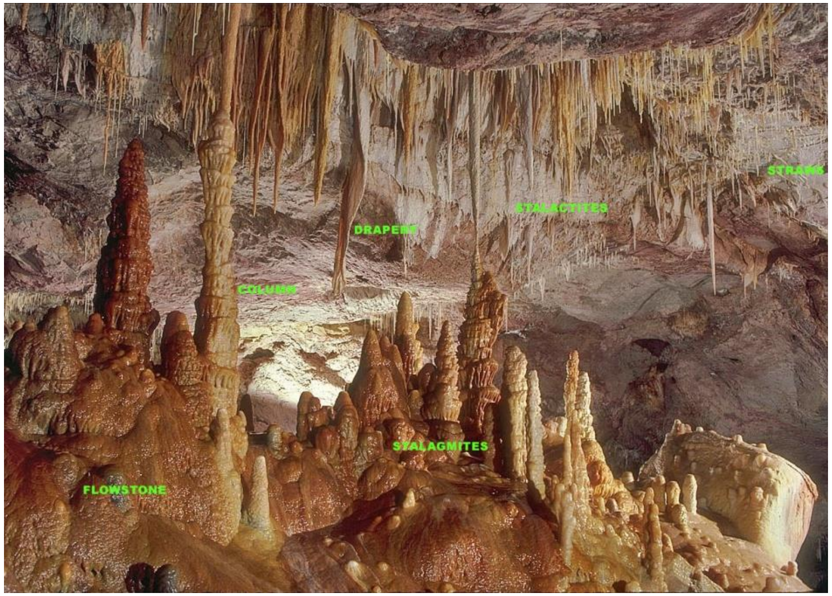


Plate tectonics

- 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)

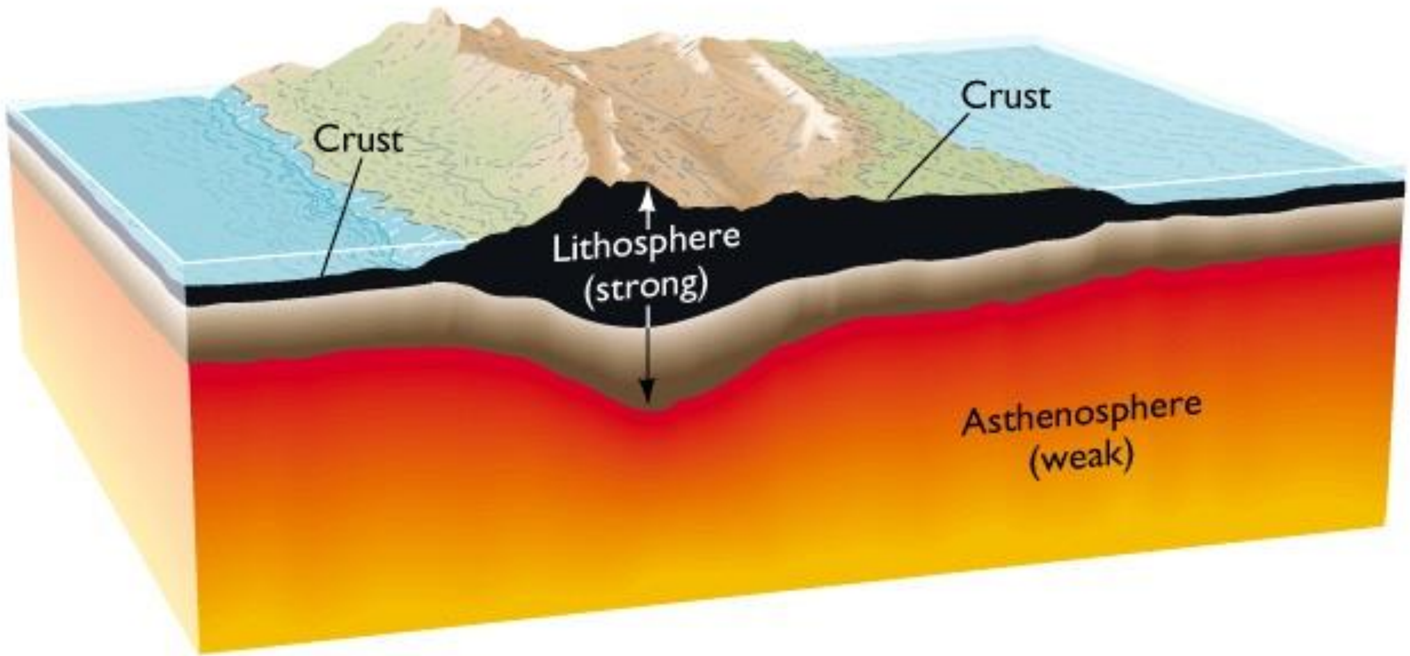
- Plate boundaries have high degree of tectonic activity
  - mountain building
  - earthquakes
  - volcanoes

Plate tectonics

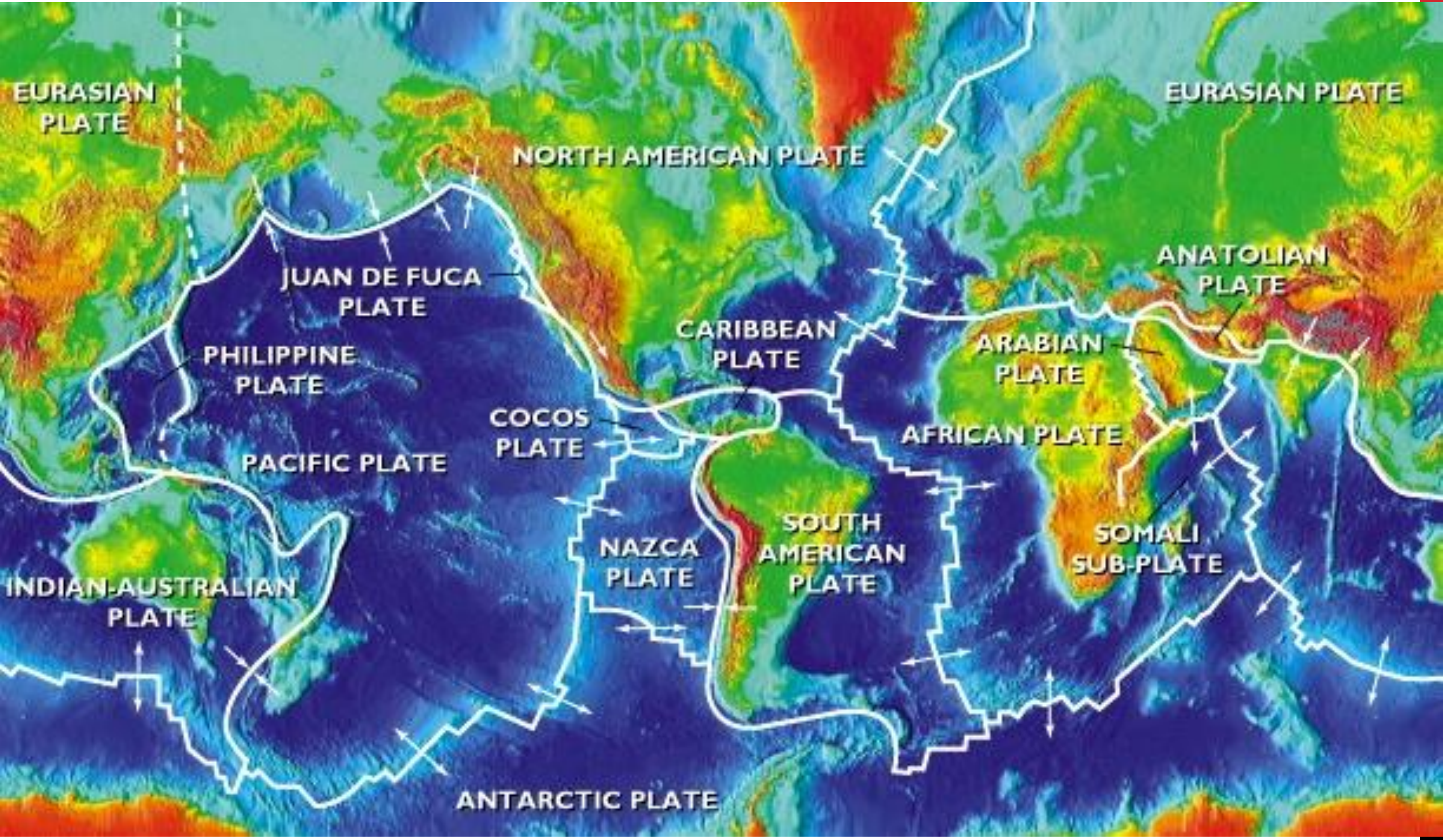
Lithosphere: **the outer rigid shell of the earth (~ 100 km). The plates are composed of this material.**

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

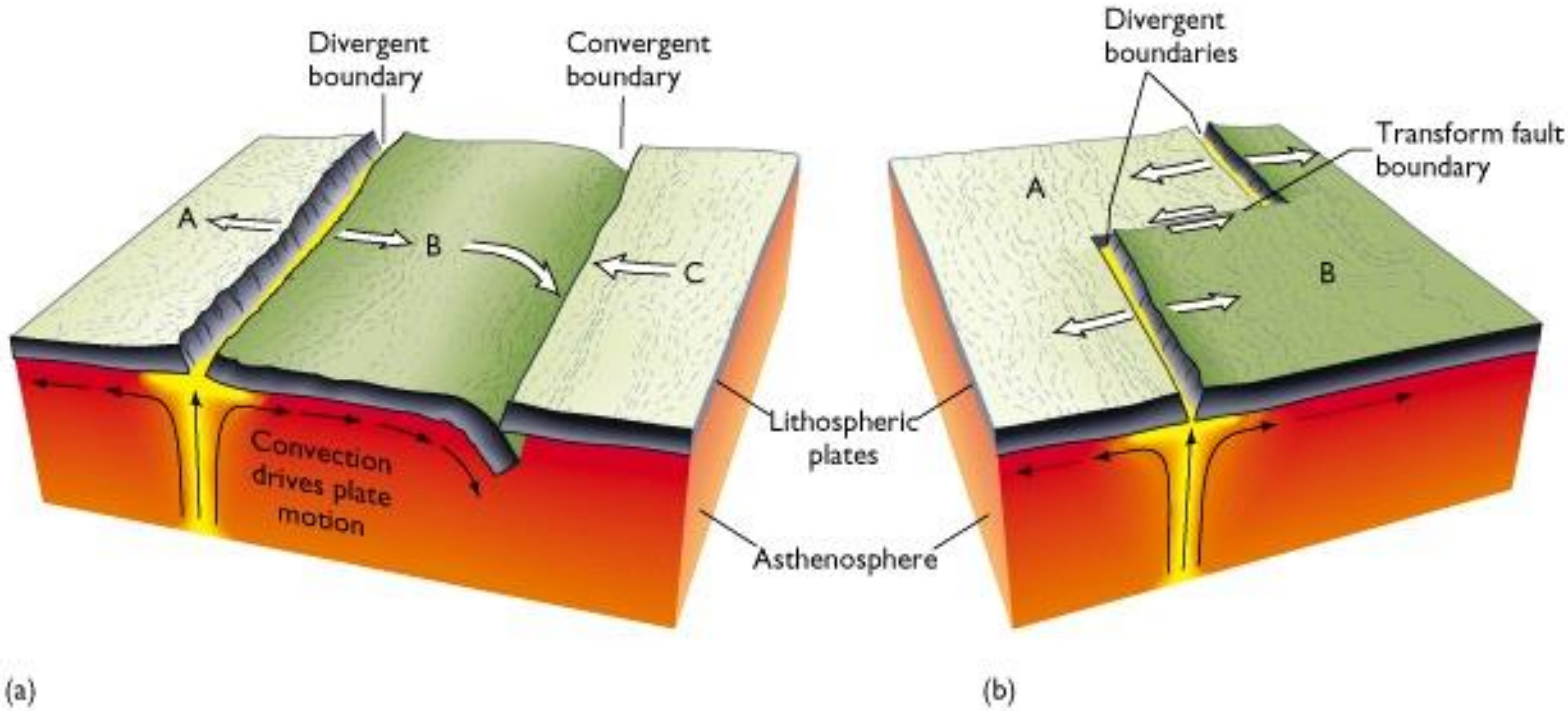
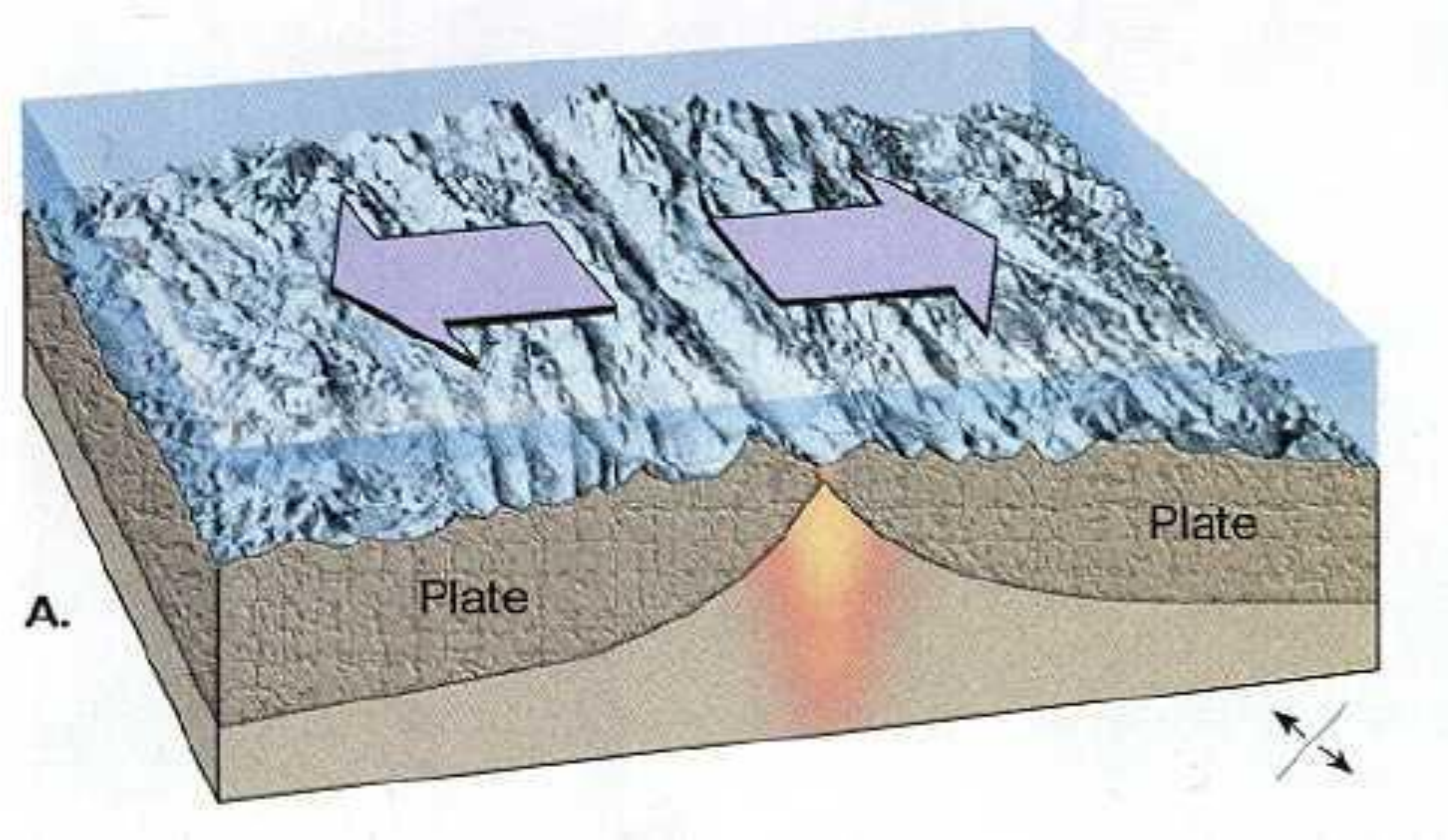


Plate Boundaries

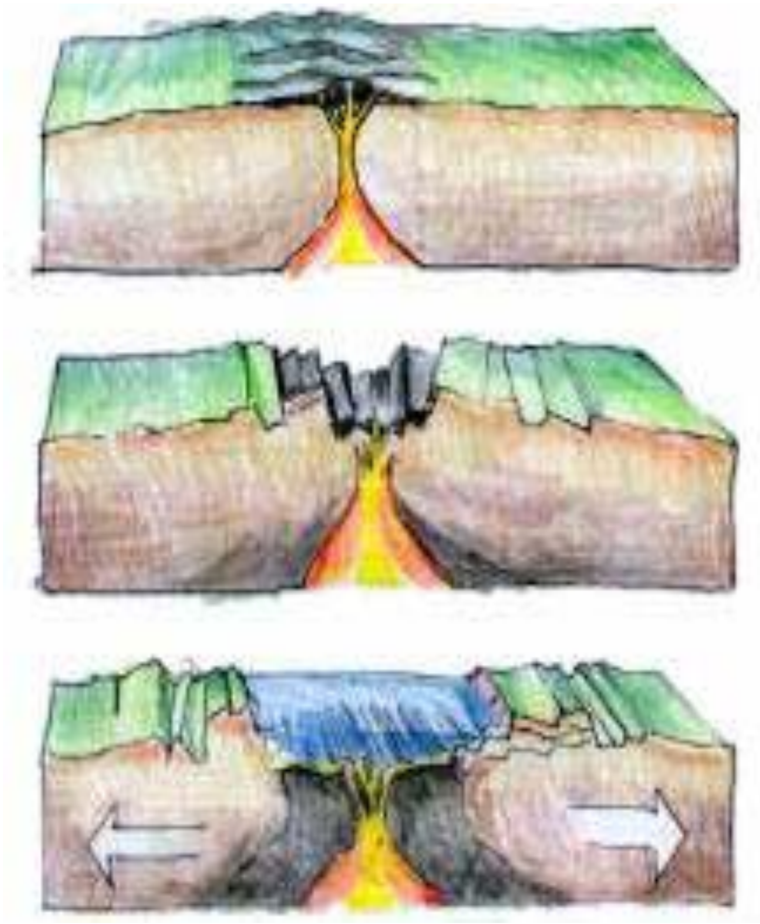
Divergent



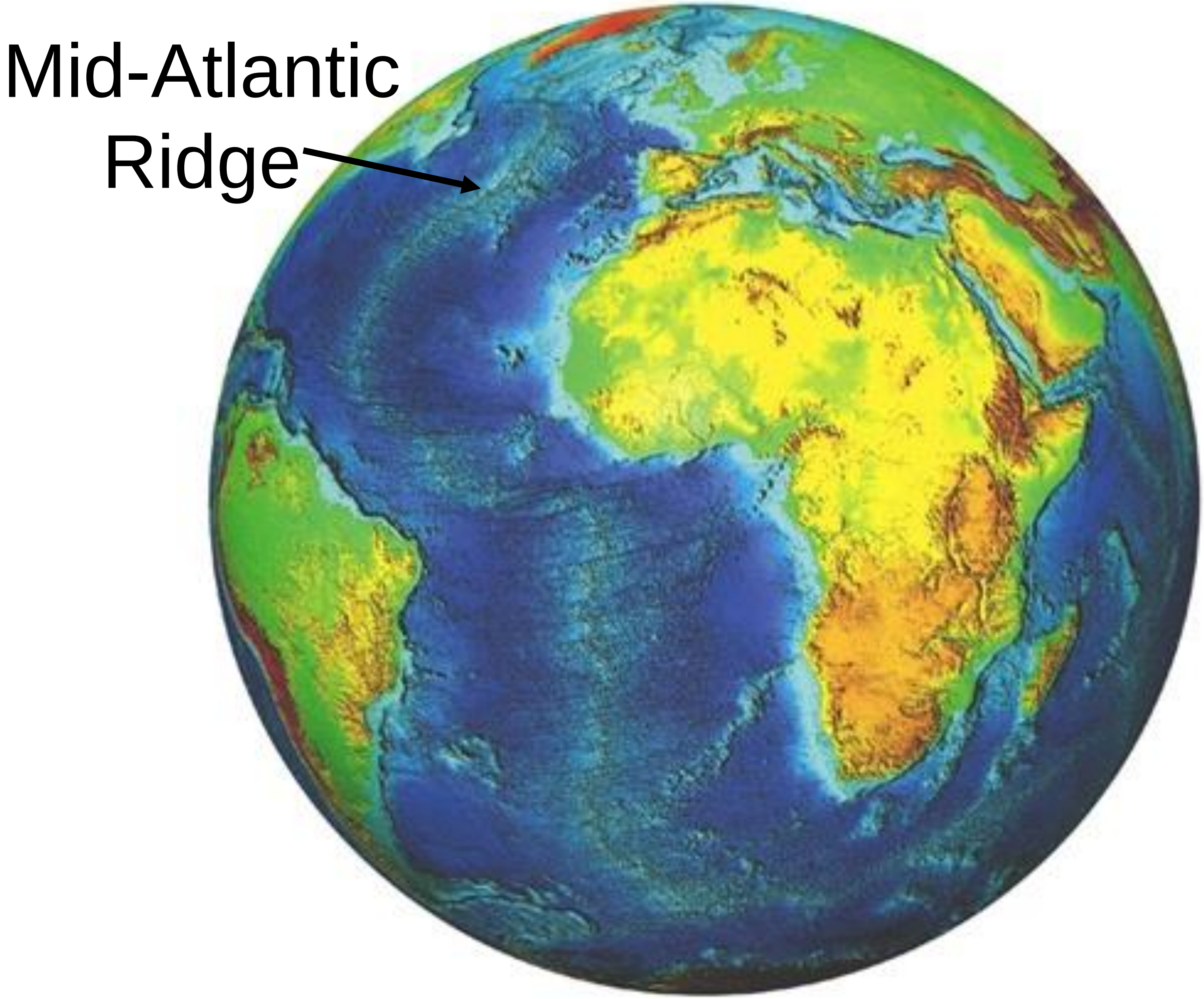
Plates move away from each other

New crust is being formed

Divergent Boundaries



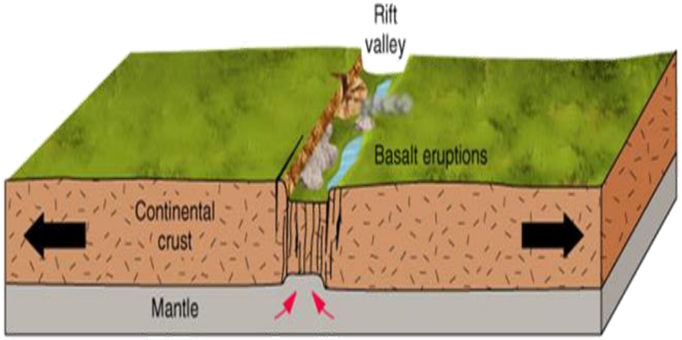
- Youngest rocks form at ridge
- Older rocks are further from ridge



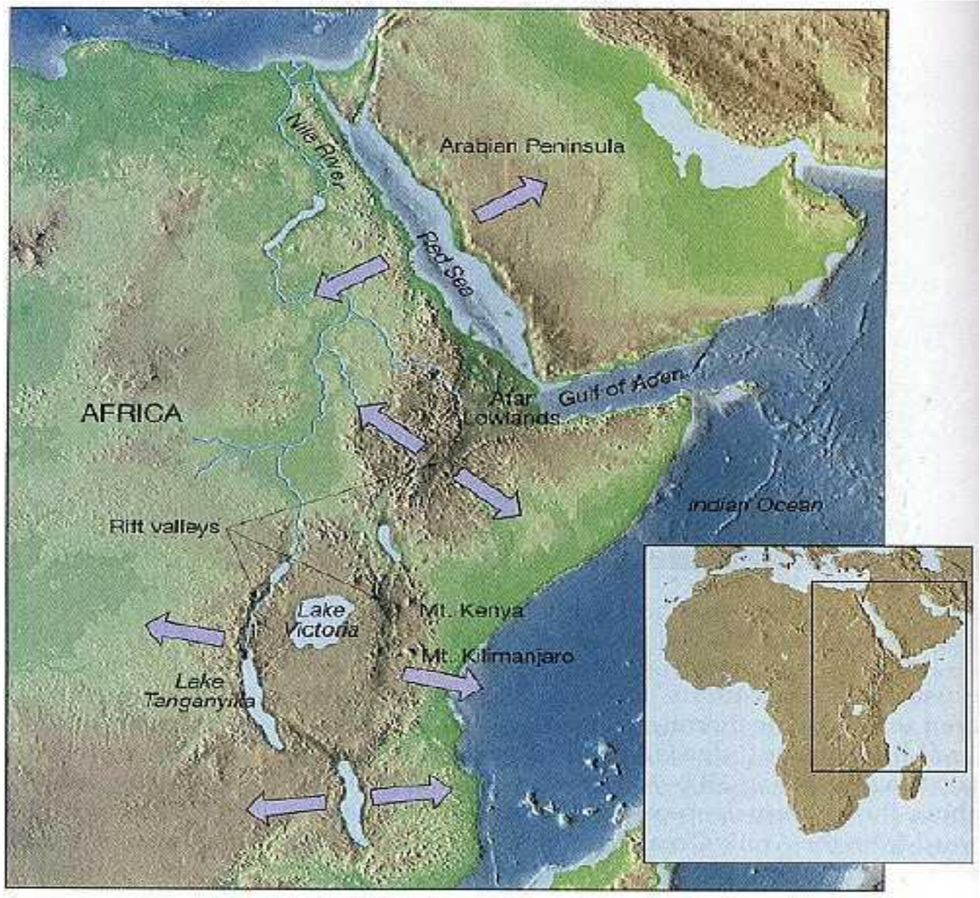
Peter W. Sloss, NOAA-NESDIS-NGDC

Divergent Boundaries

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.

Fig. 1.15

Convergent Boundaries

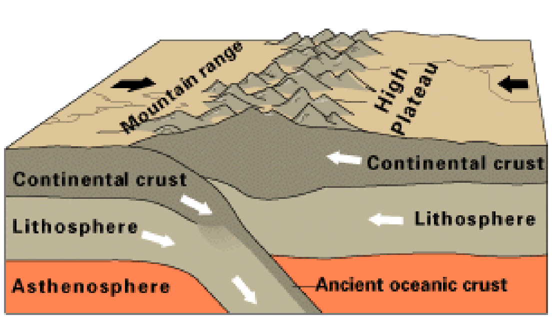
- Plates are moving toward each other

- Crust is being destroyed

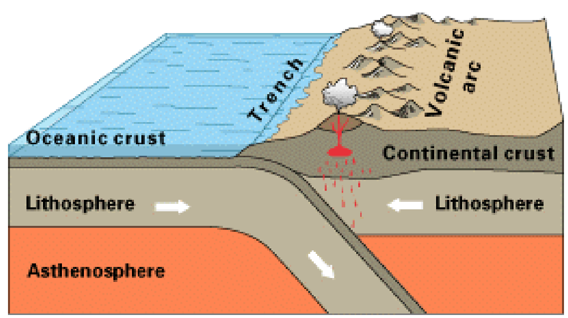
- Three Types:
  - Ocean-continent
  - Ocean-ocean
  - Continent-continent

Convergent Boundaries

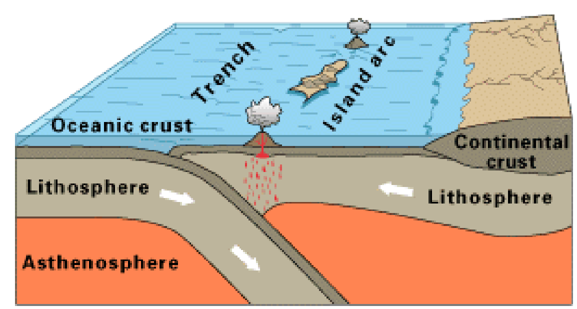
- Destroys old crust and forms new mountains
- Three types of convergent boundaries



Continental-continental convergence



Oceanic-continental convergence

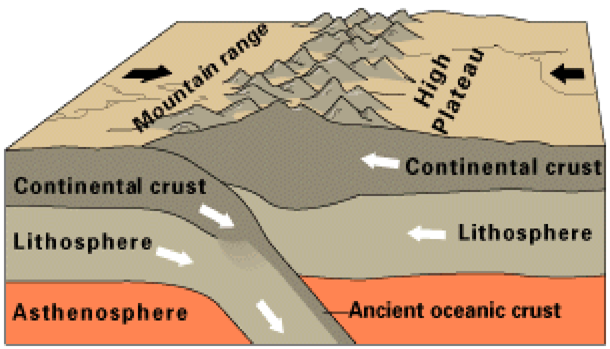


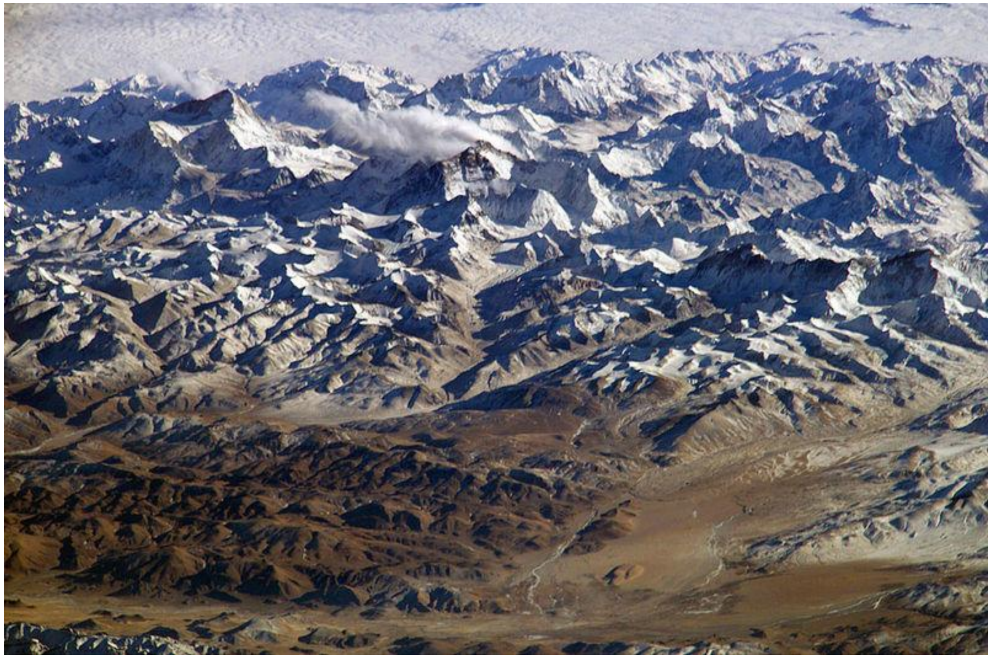
Oceanic-oceanic convergence

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**..*

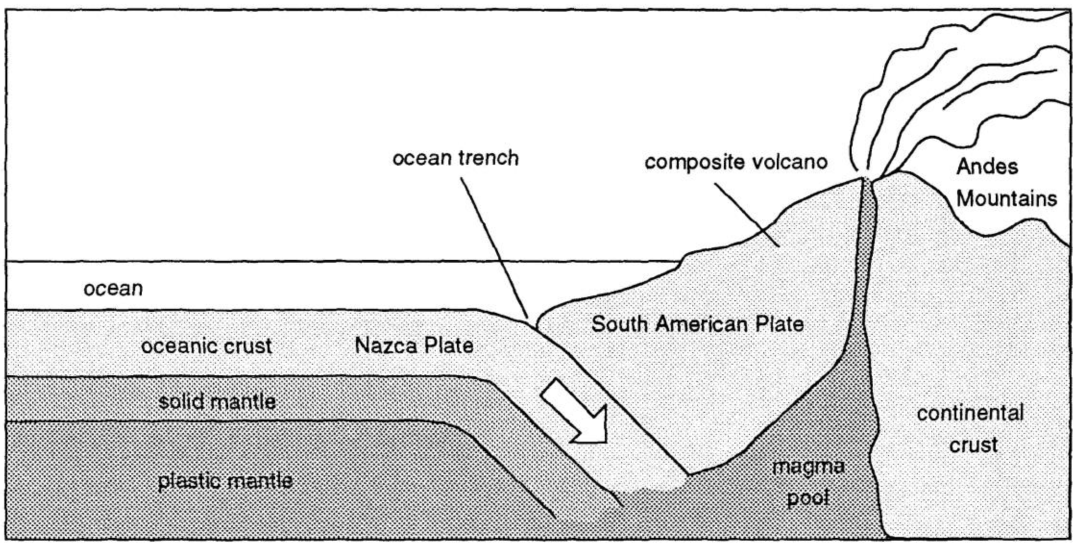


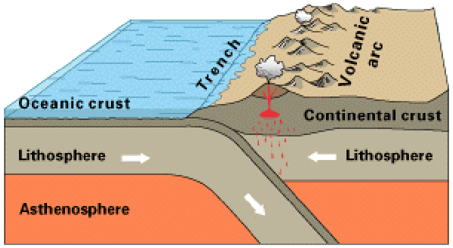
Fig. 8–3. Subduction of the Nazca Plate below the South American Plate forming composite volcanoes

Denser oceanic plates always subduct beneath less dense continental plates

Convergent Boundaries

Ocean-continent convergence

Trench & Coastal Volcanoes



Oceanic-continental convergence

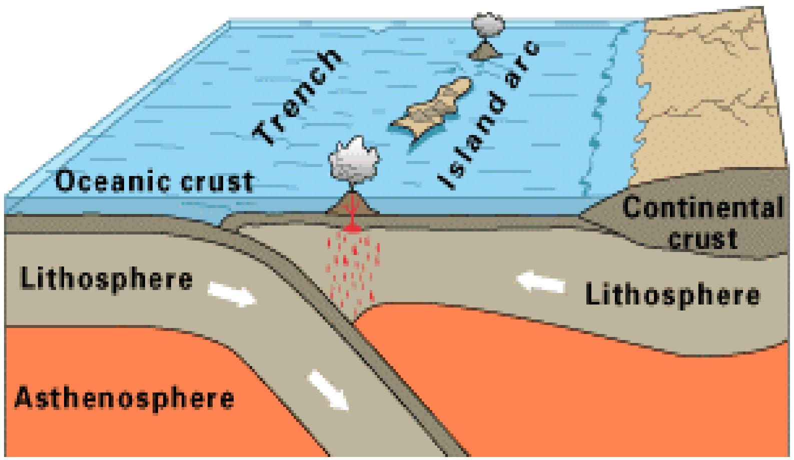
Convergent Boundaries

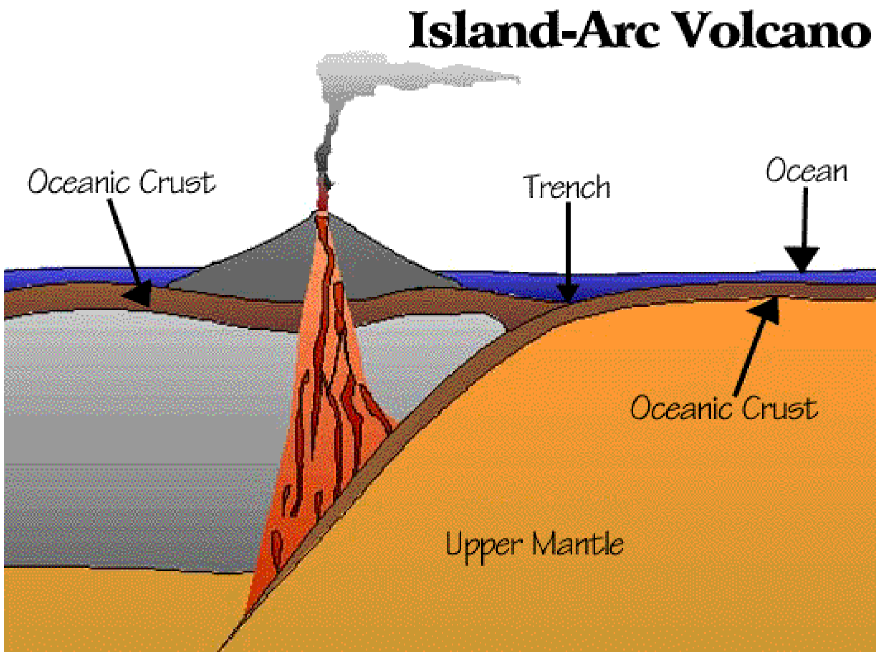
Ocean-continent convergence

Convergent Boundaries

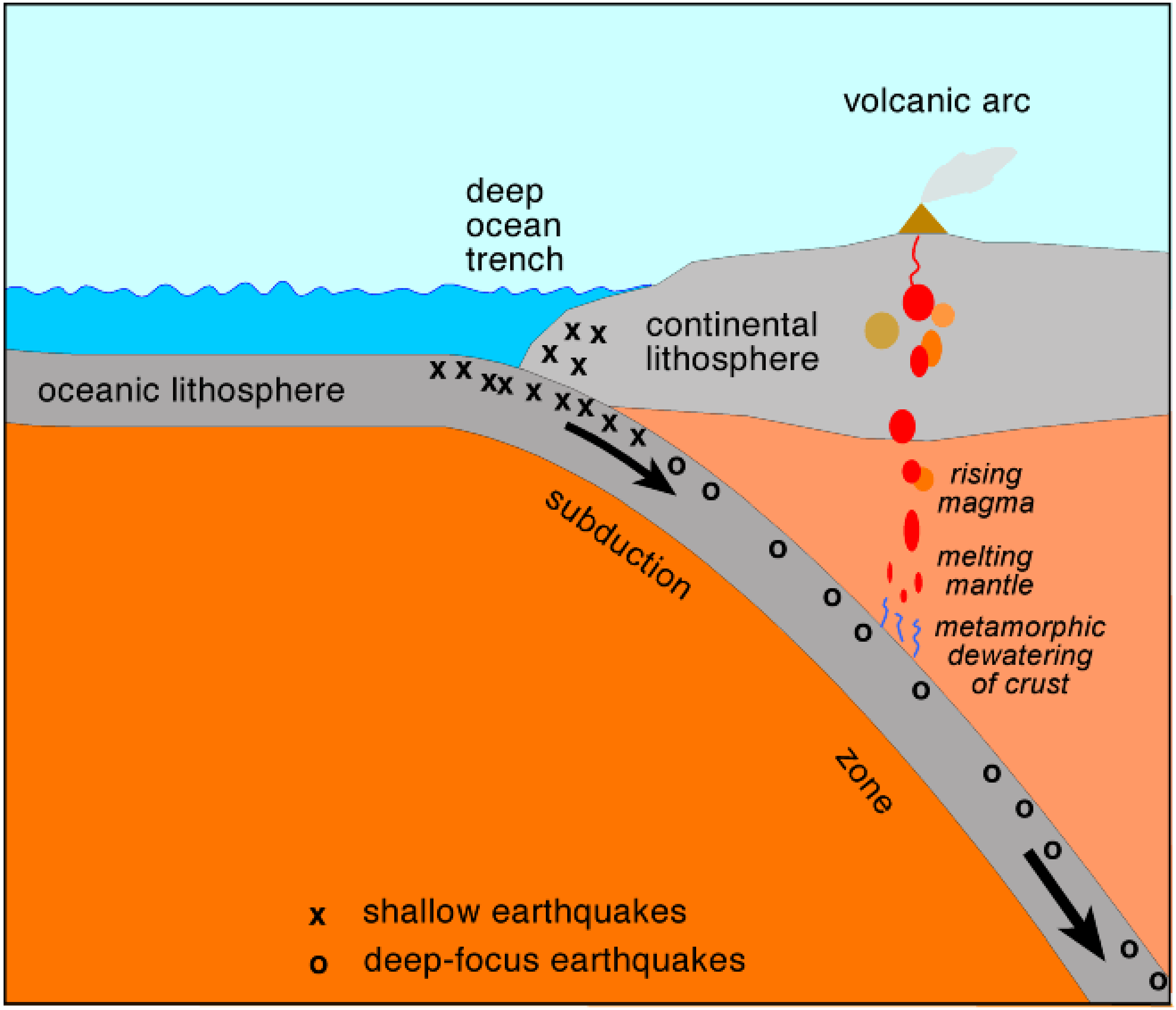
Ocean-ocean convergence

Trench & Island arc





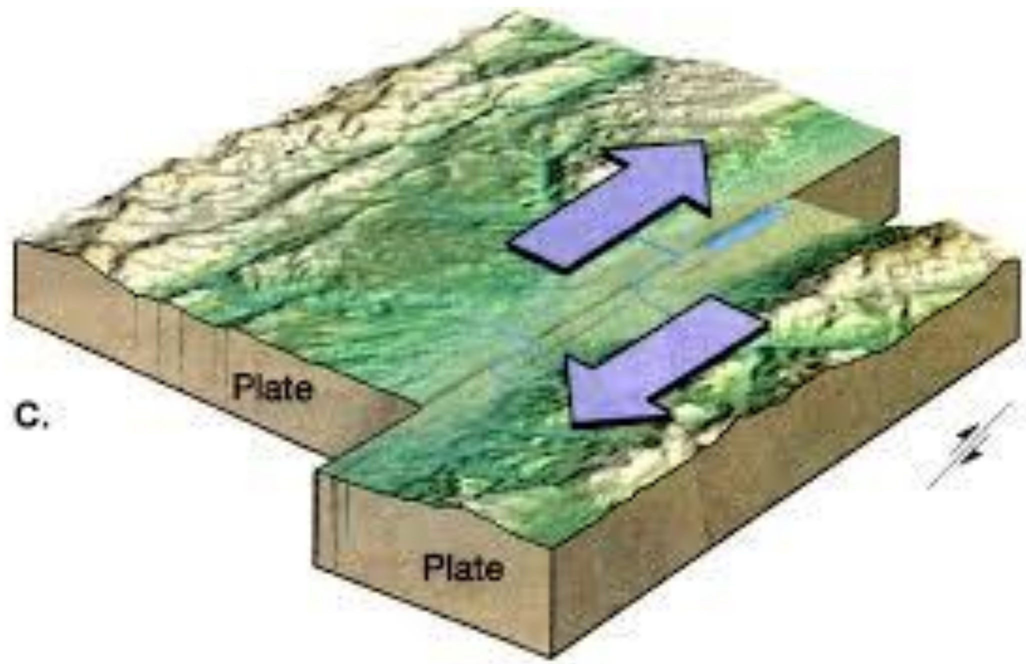
FLUX MELTING



Transform plate boundary

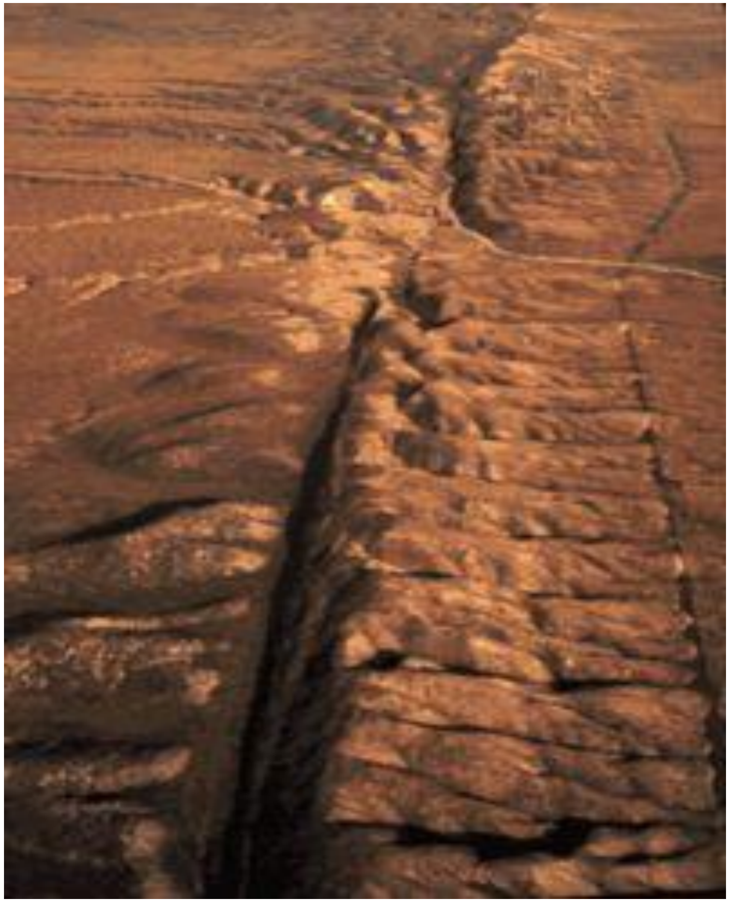
- Crust is neither created nor destroyed

Plates slide past one another



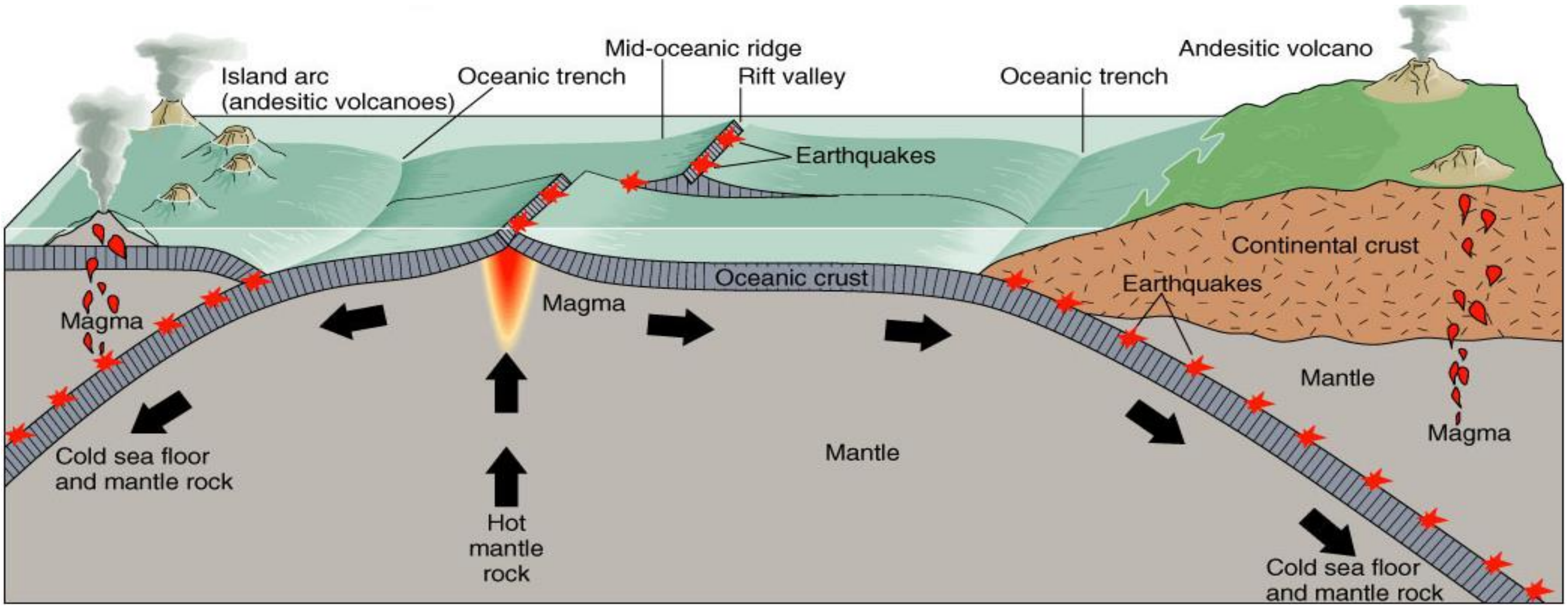
Transform plate boundary

San Andreas Fault



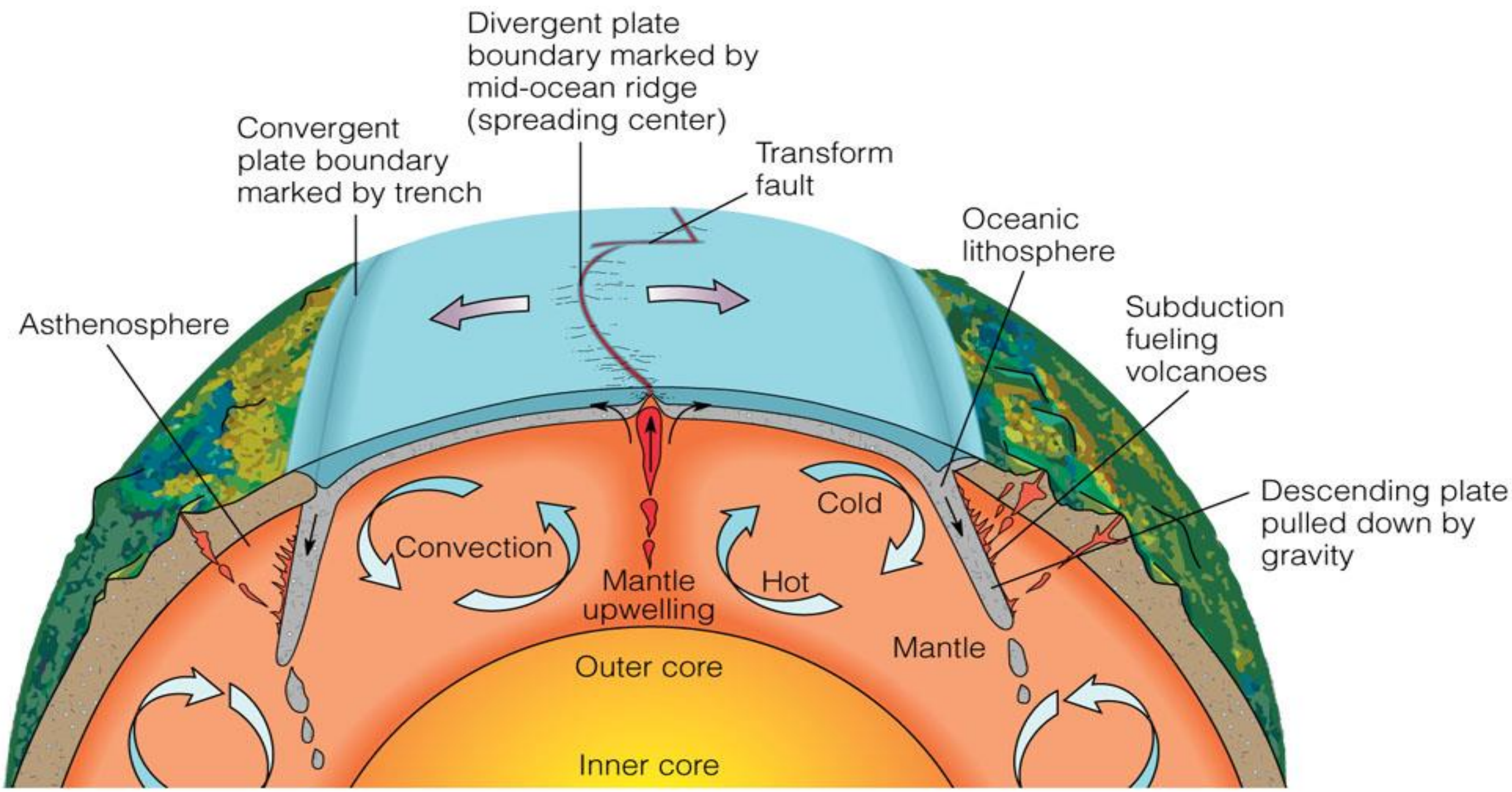
Carrizo Plains, Central California

Summary of Plate Movements



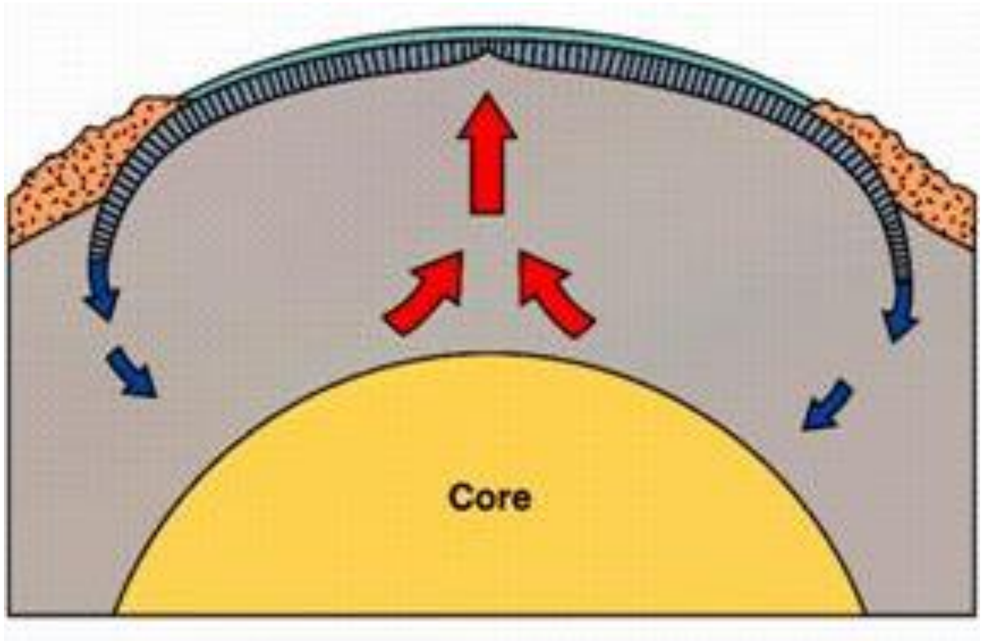
Convection currents

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



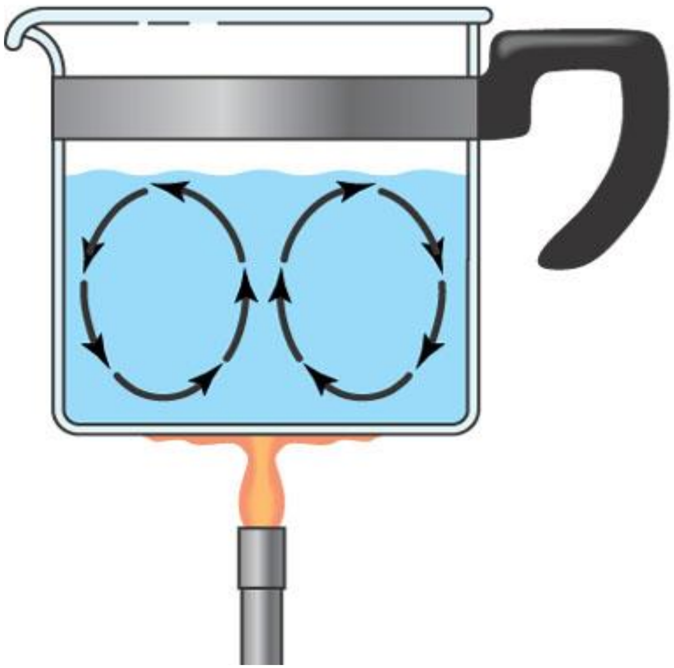
Convection currents

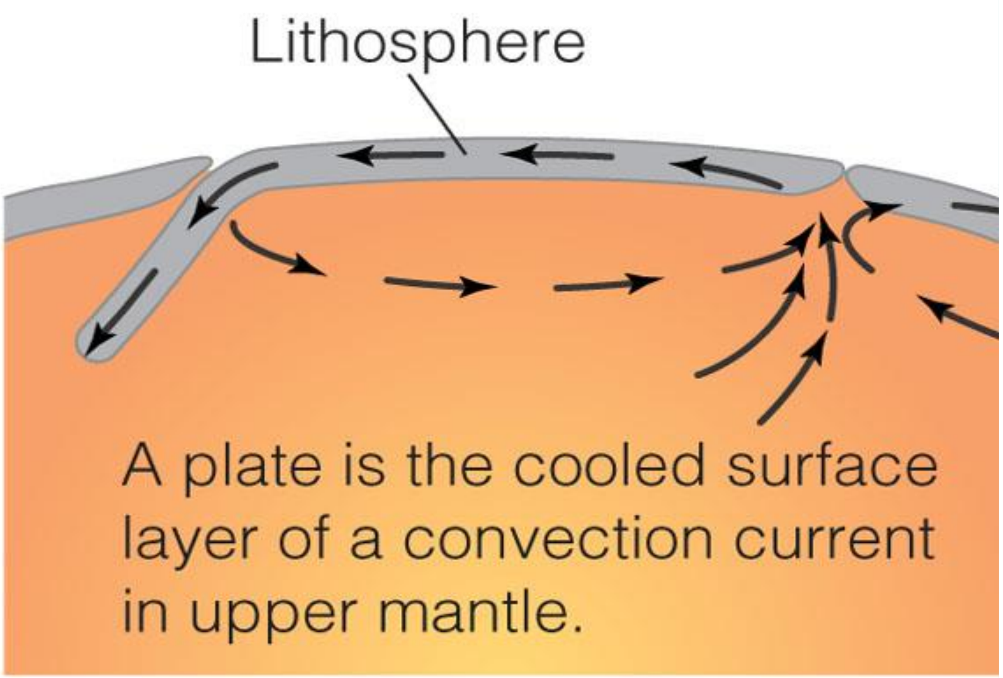
Driving force for convection?



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

Convection currents





How deep does the convection occurs?

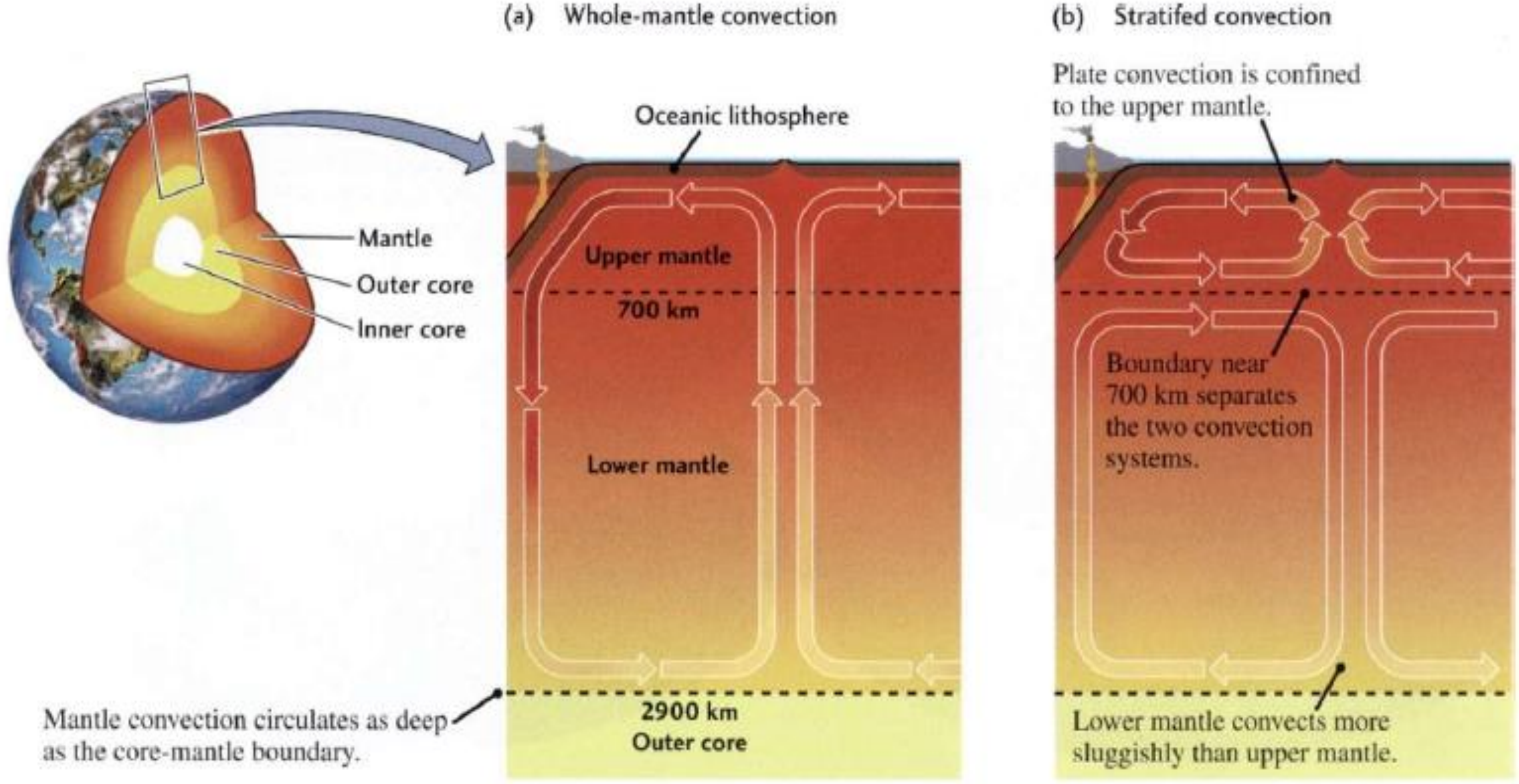


Figure 2.14 Two competing hypotheses for the mantle convection system.

Two competing hypotheses for the mantle convection system

Rates and History of plate movements

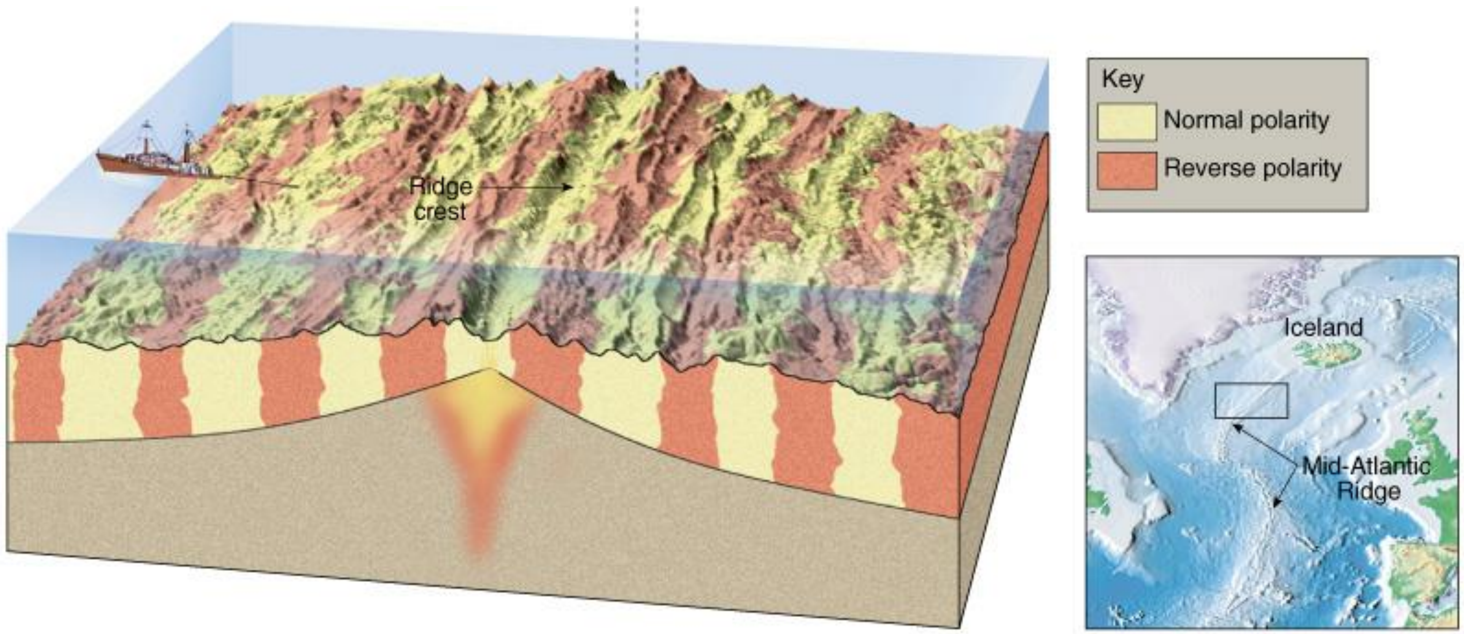
How fast do plates move?

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

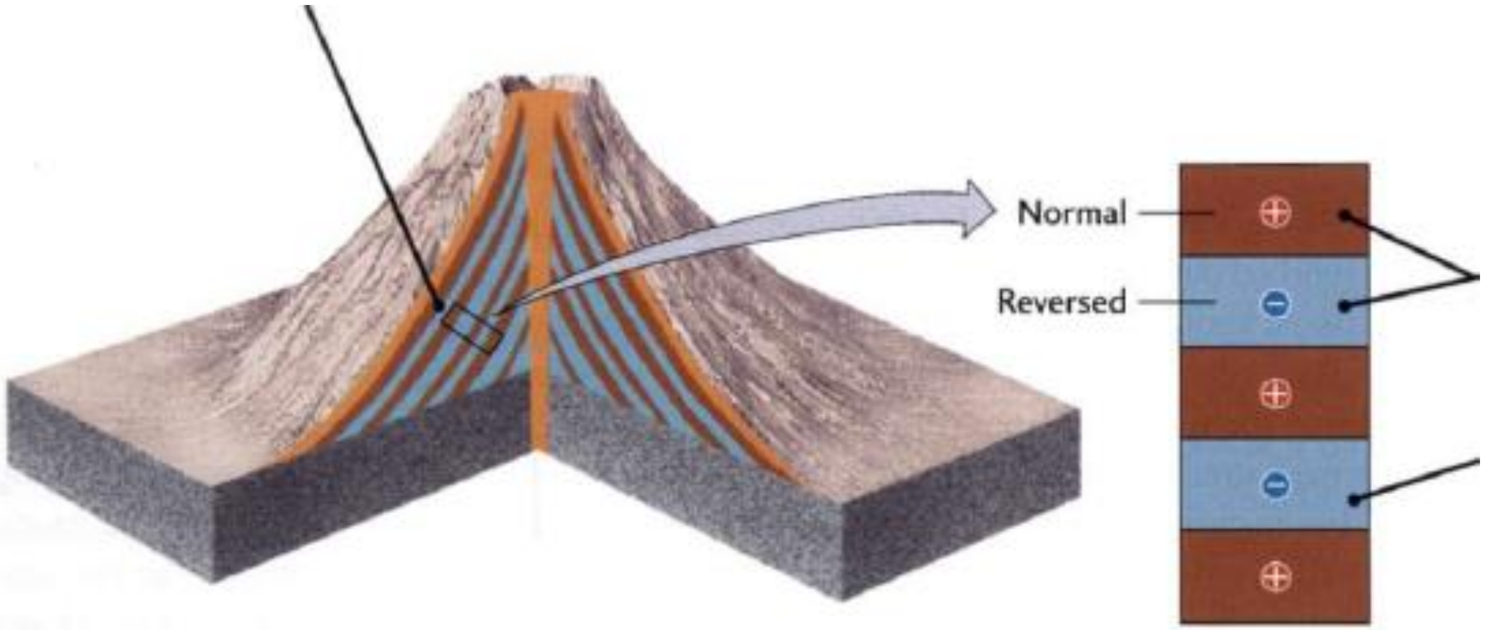
Paleomagnetism



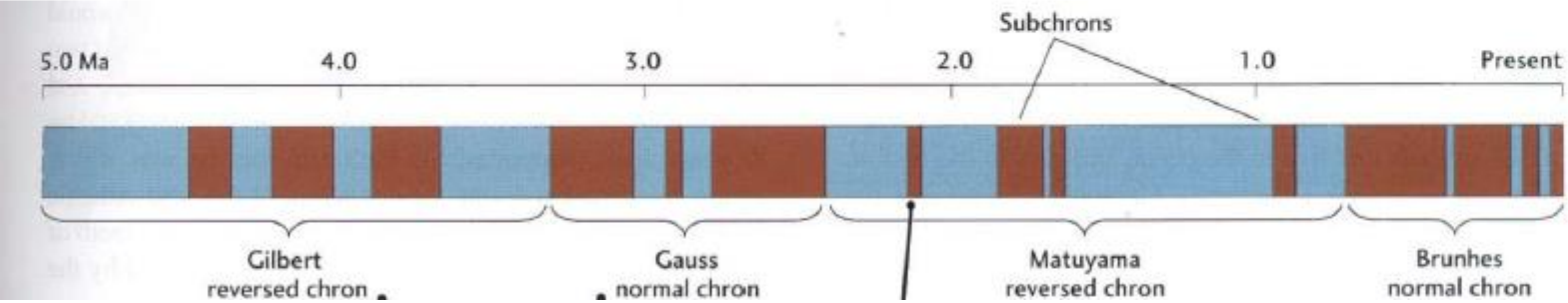
B. Research vessel towing magnetometer across ridge crest

C. Location map

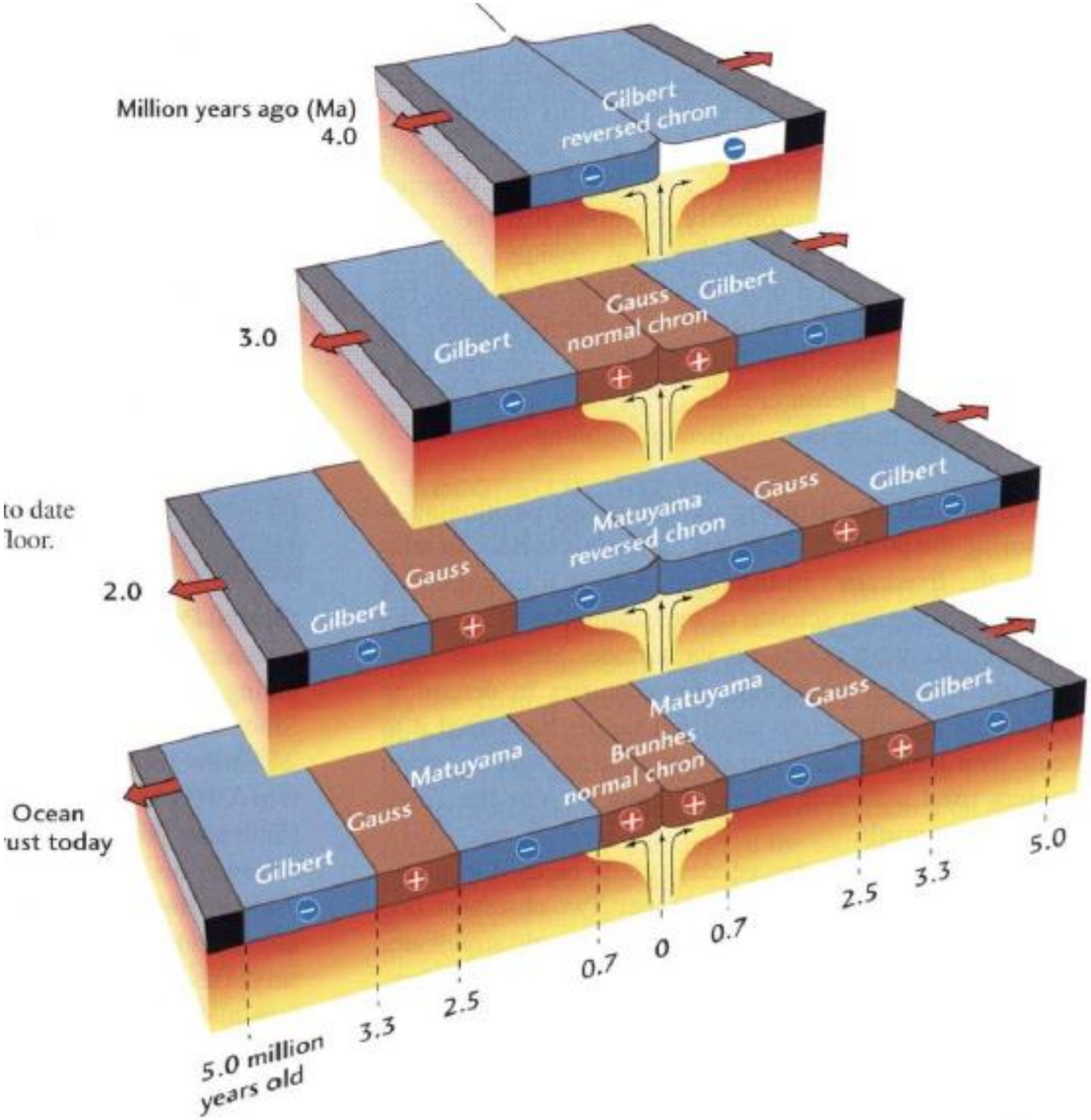
Paleomagnetism



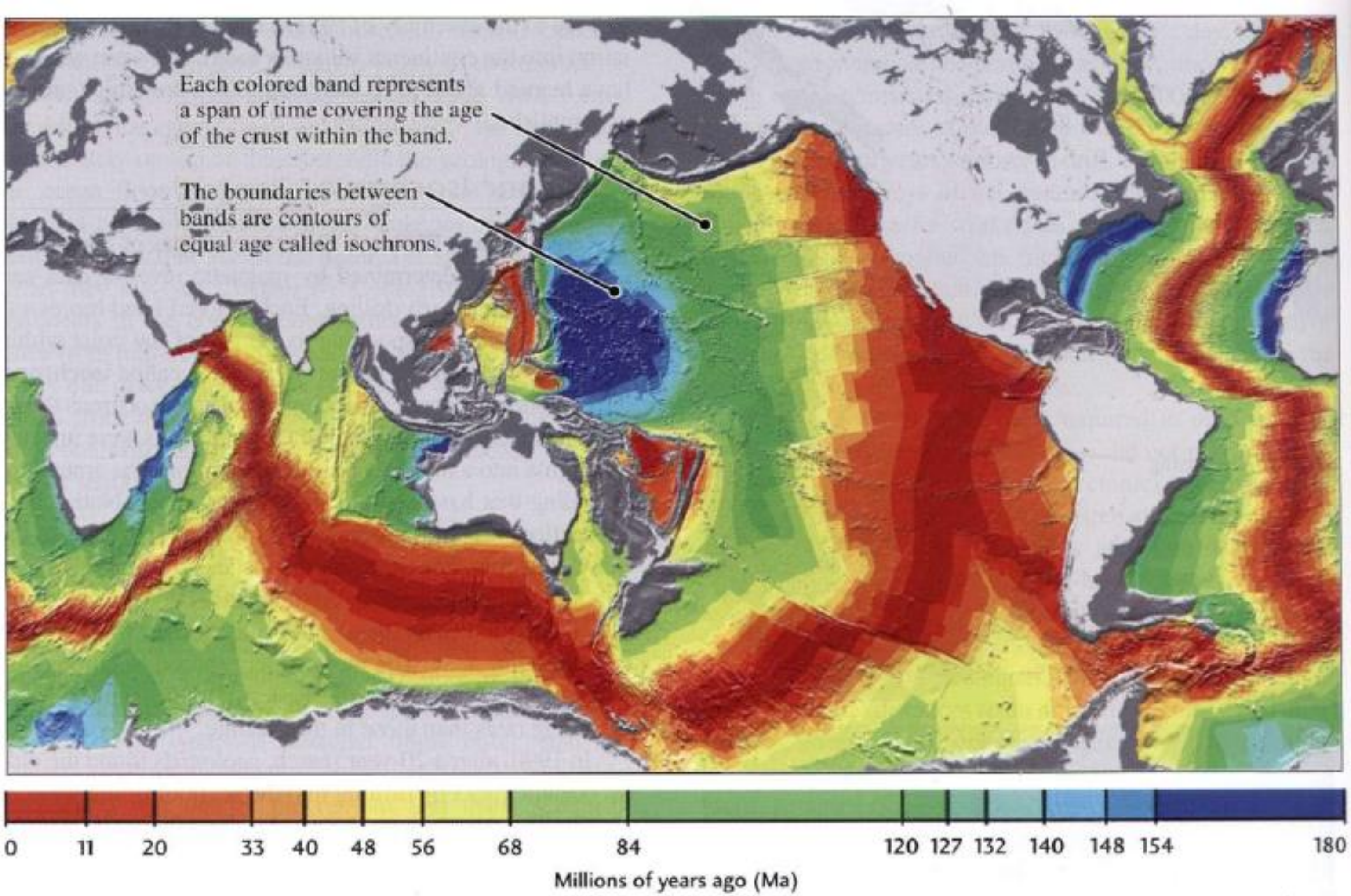
Paleomagnetism



Paleomagnetism



The global isochron map of the ocean floor



Reconstructing history of plate movements

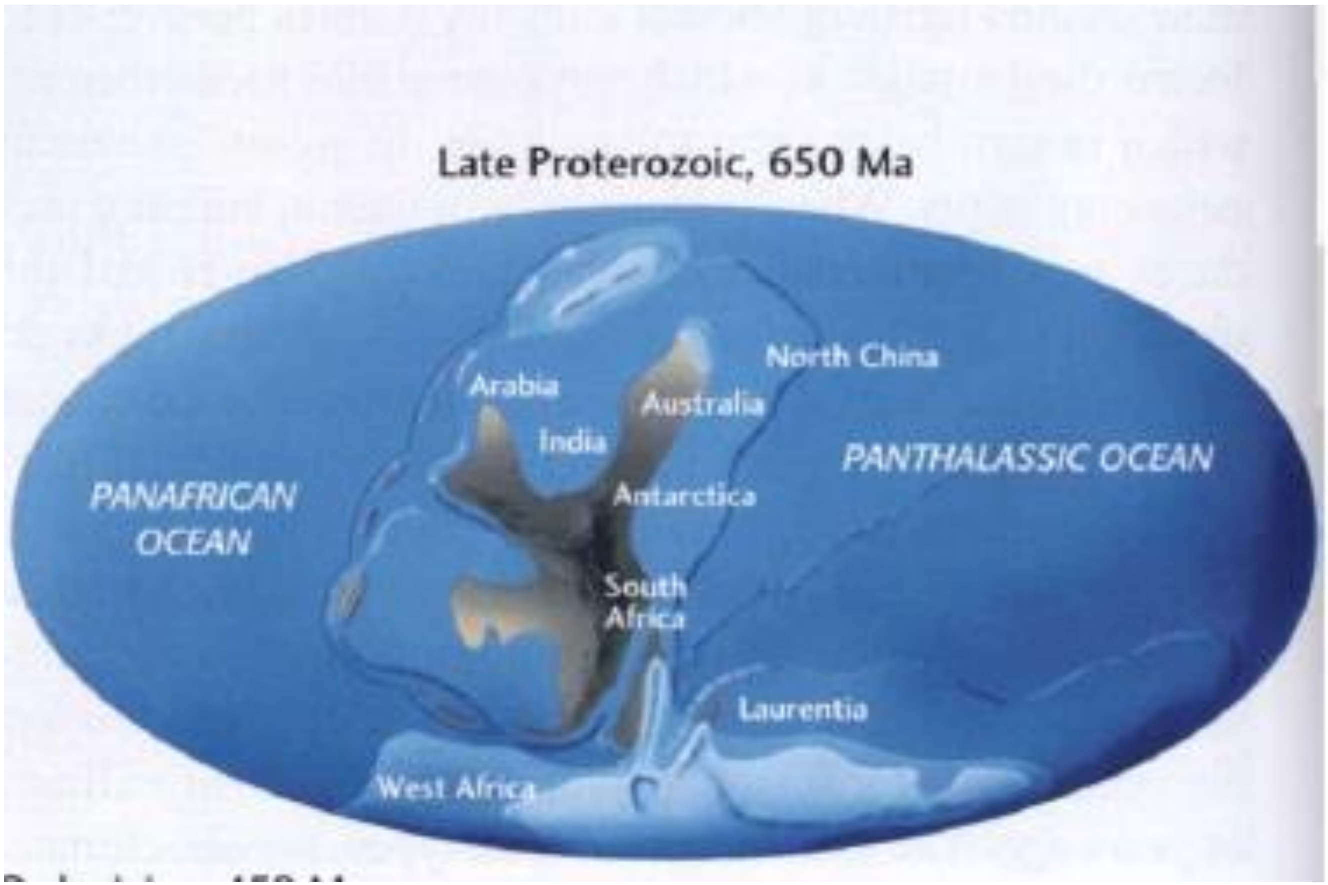
-Sea floor isochron

-Transform fault boundaries

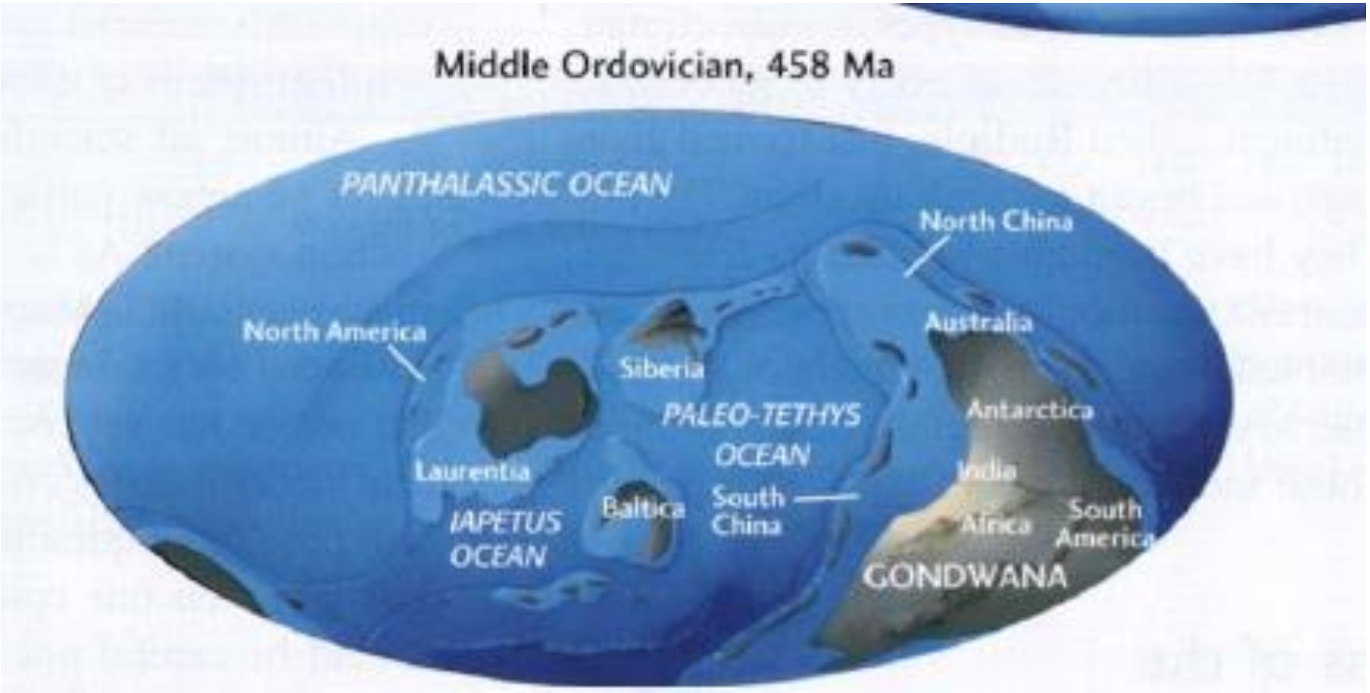
- Evidences also derived from rock types, fossils, mountain belts etc

Assembly of Pangaea

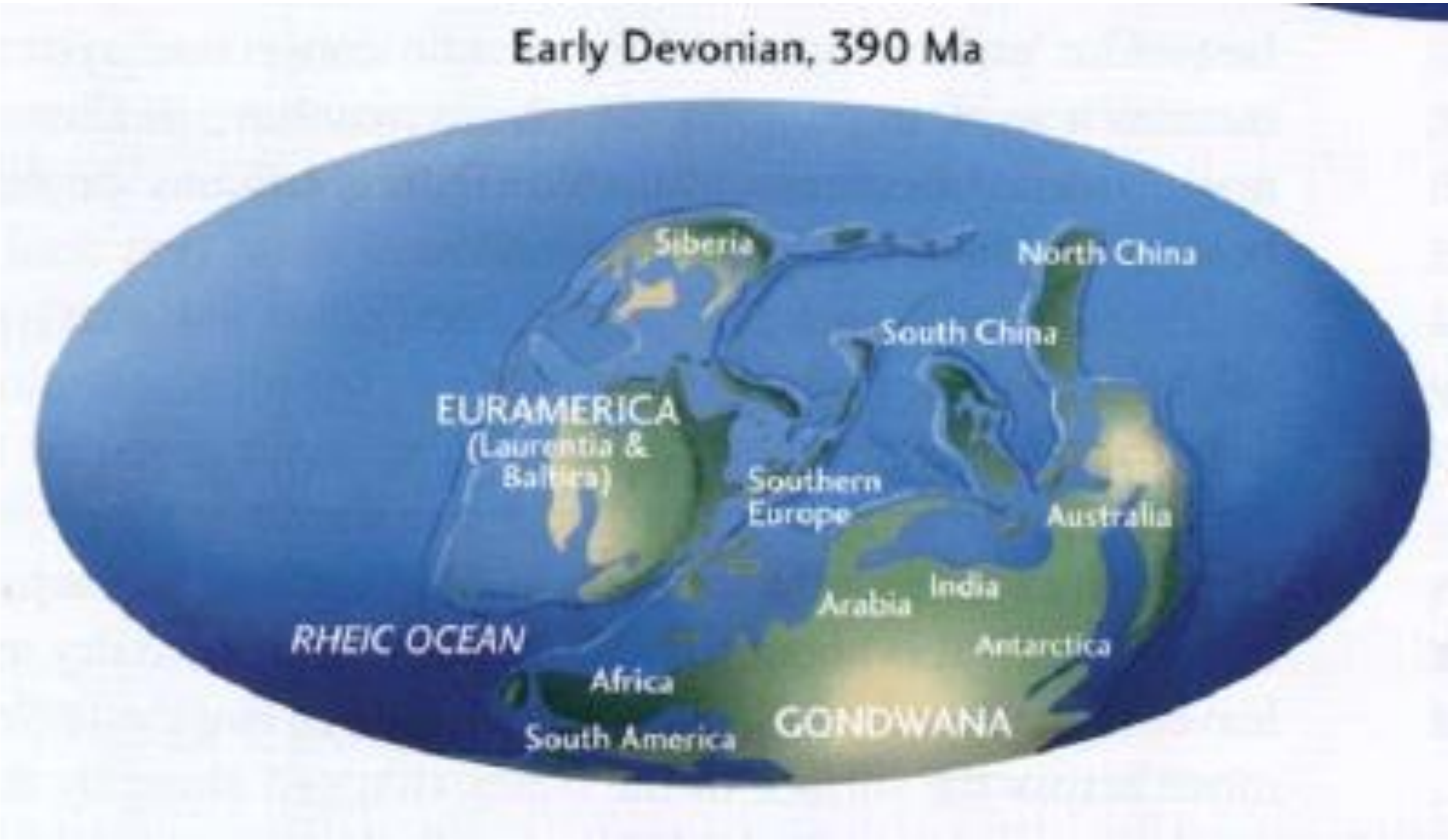
Assembly of Pangaea



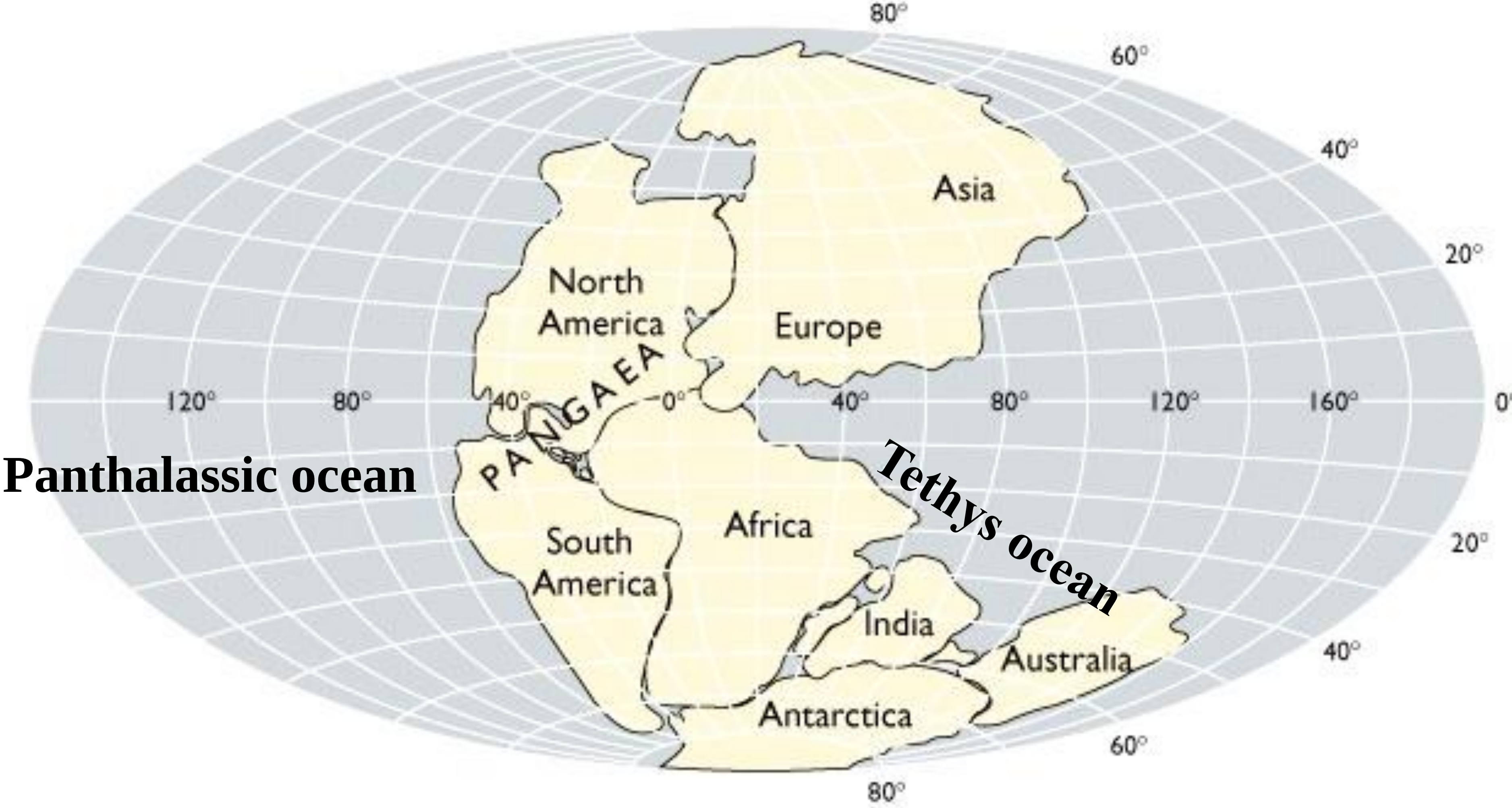
Assembly of Pangaea



Assembly of Pangaea

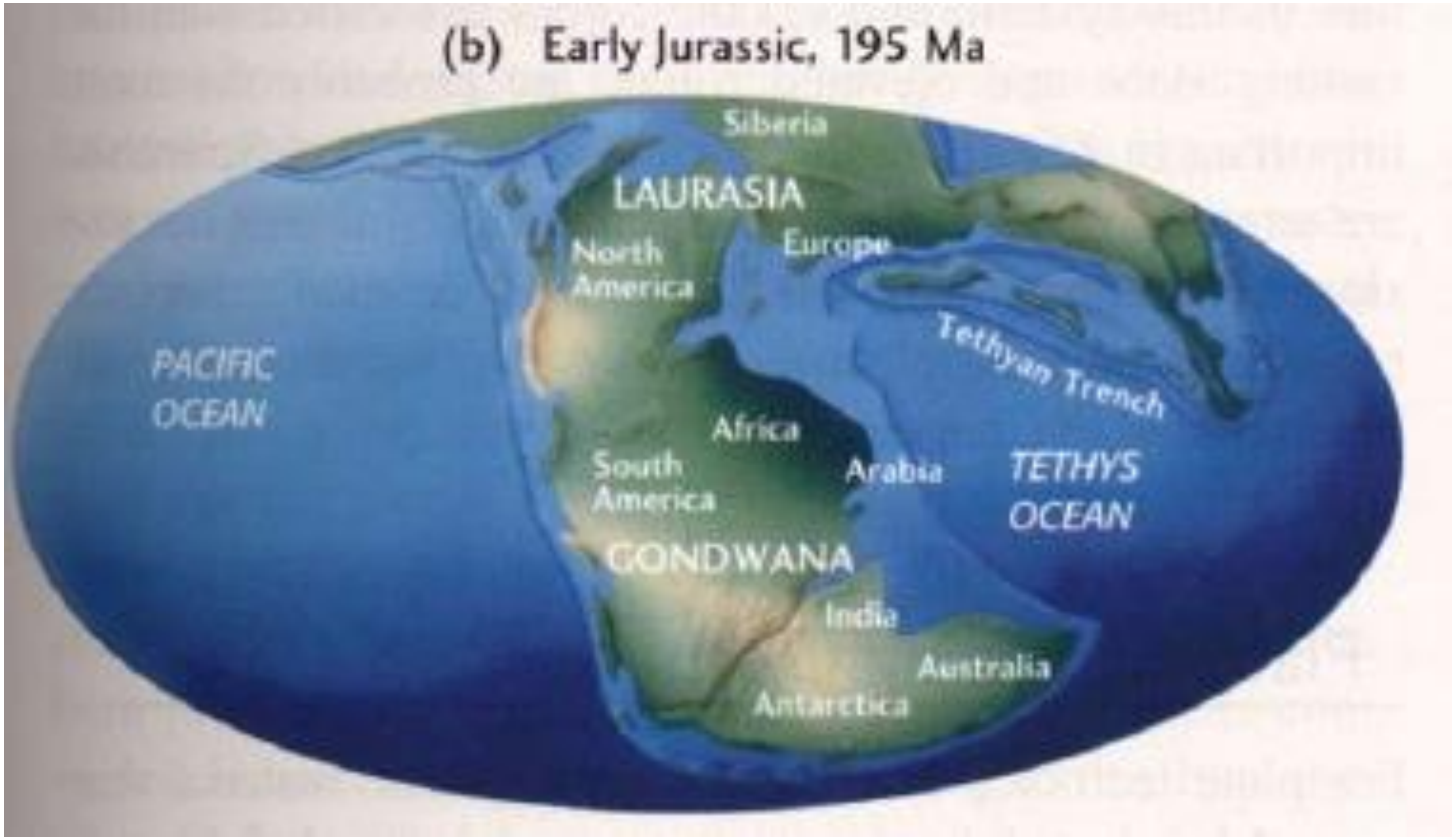


THE SUPERCONTINENT OF PANGAEA (237 MILLION YEARS AGO)



Break up of Pangaea

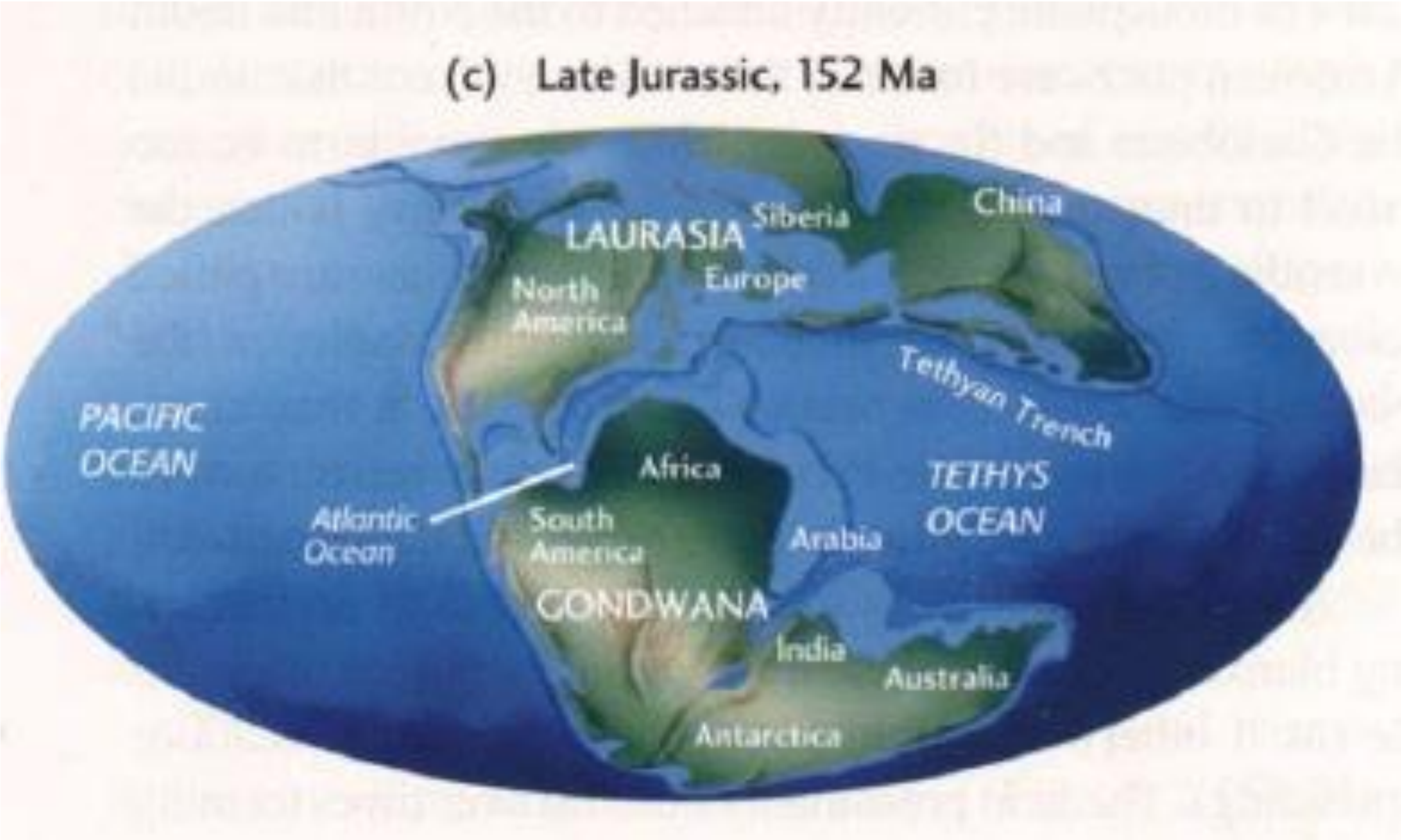
Evidence-rift system-volcanic rocks from Nova Scotia and North Carolina



Break up of Pangaea

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

-Southern continents and northern continent split up



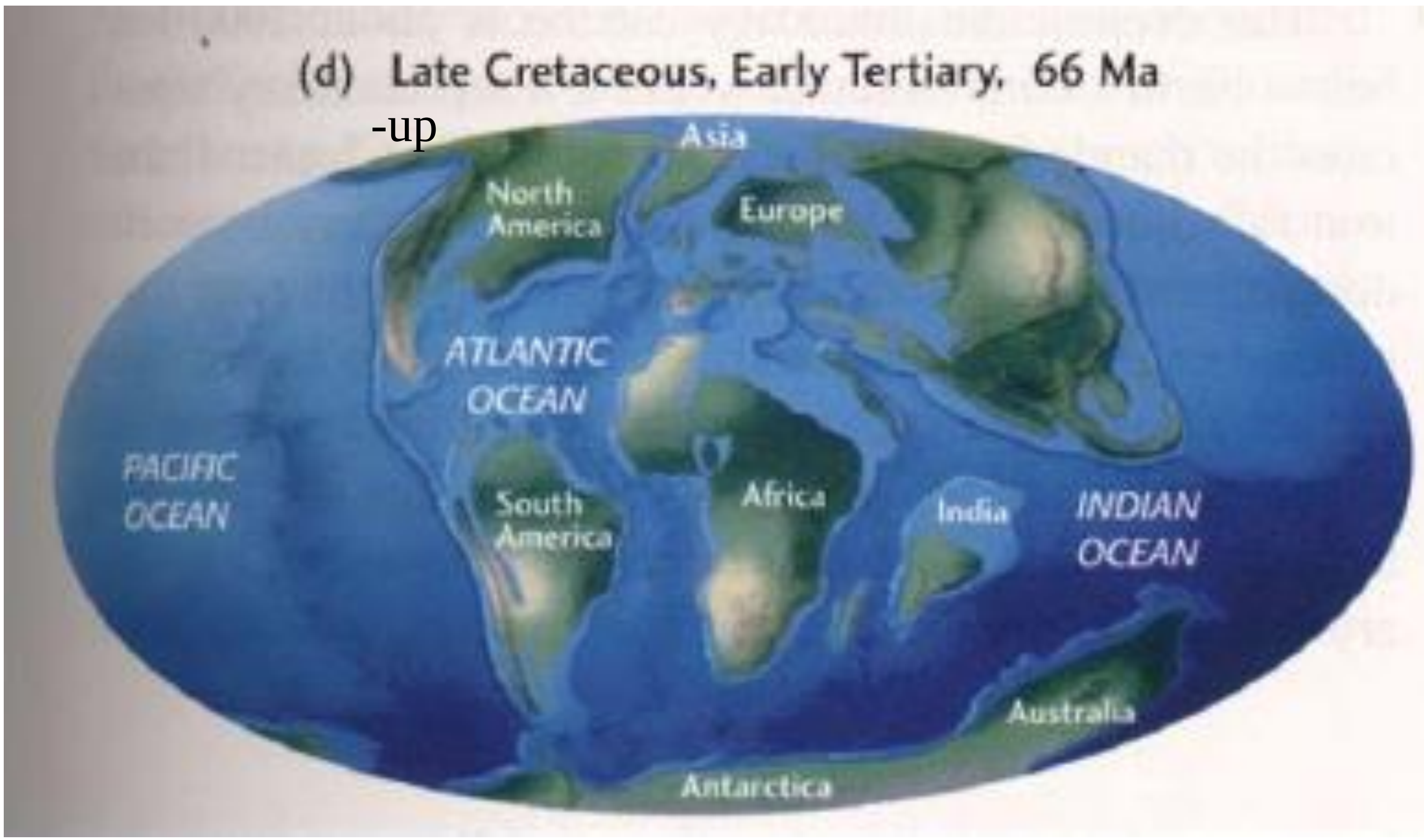
Break up of Pangaea

Early stage of break up- Atlantic ocean opened and widened

-Tethys ocean was closing to form Mediterranean

- India was well going northward

-up

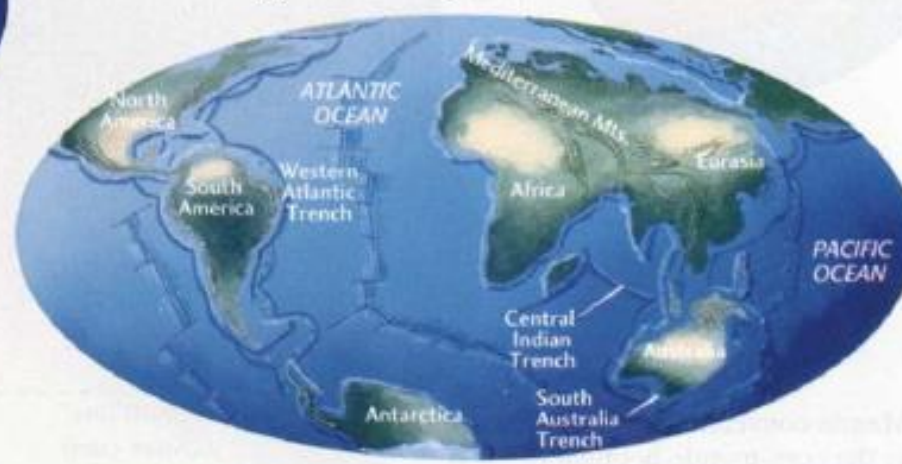


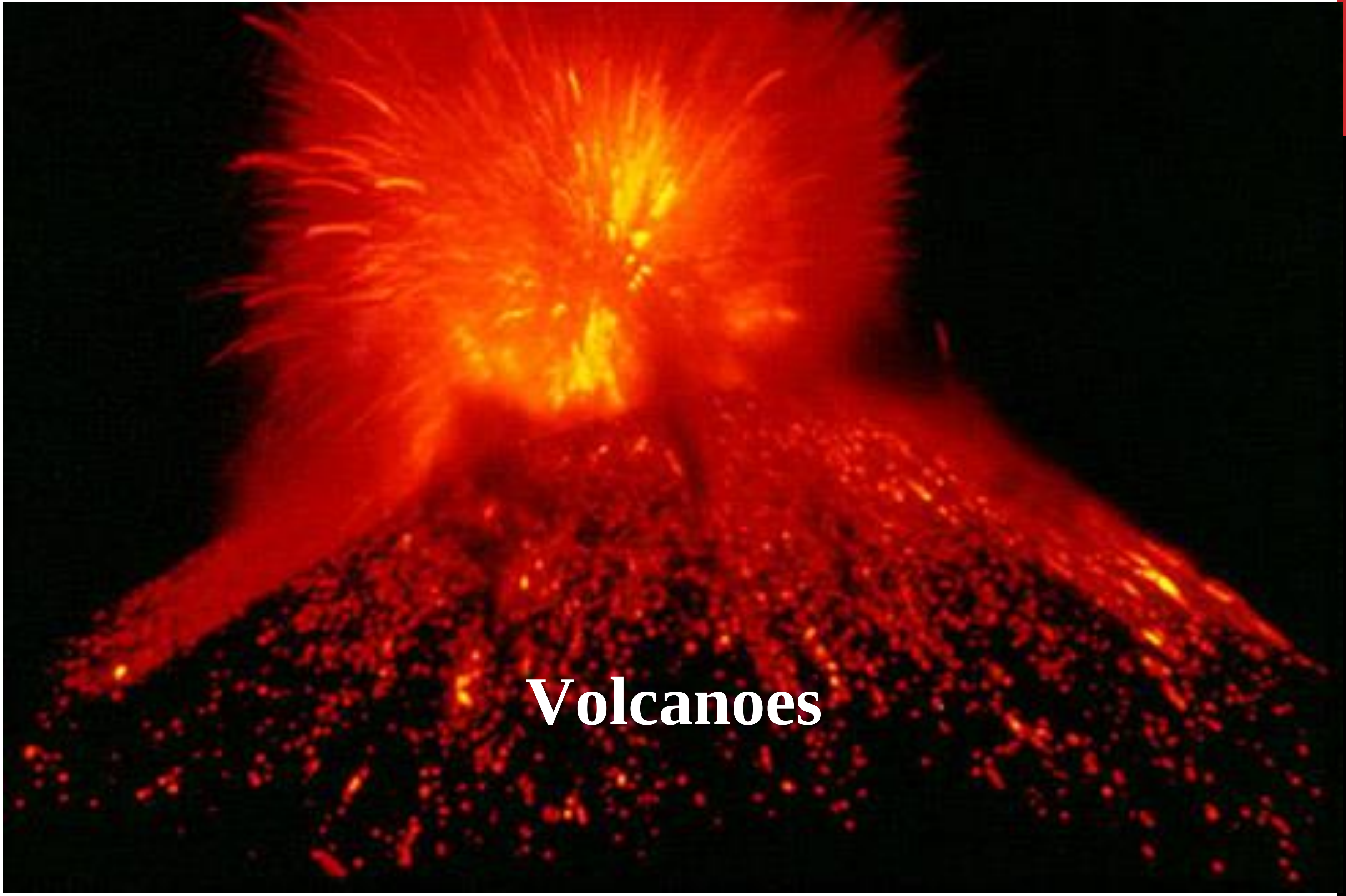
The present day and future world

(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

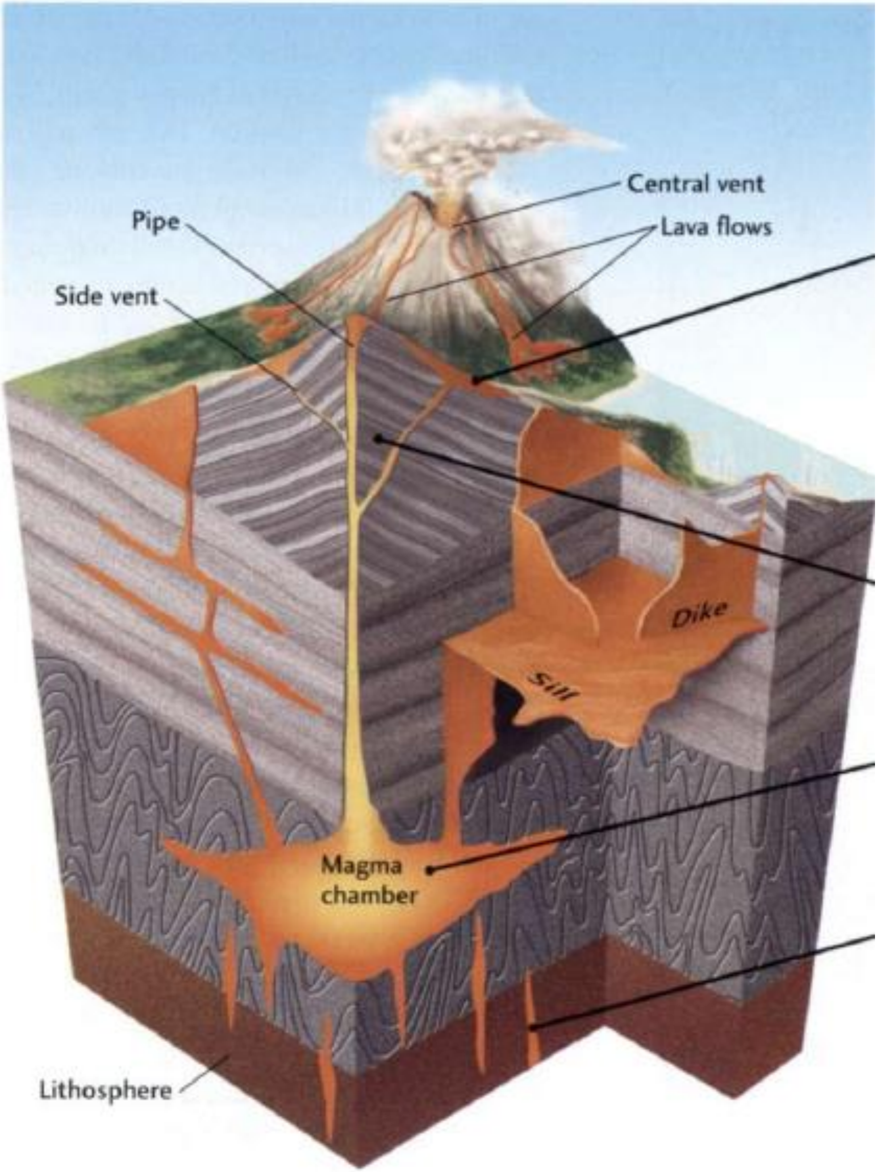



Volcanoes

Eruption at Pompeii

MAY 1990 ERUPTION OF KILAUEA, HAWAII

Plumbing System of a Volcano



Lava accumulates on the surface to form volcano

Lava erupts through a Central and side vents

Rise through the lithosphere

Originates from the Asthenosphere

Types of Lavas

- Basaltic Lavas
- Andesitic Lavas
- Rhyolitic Lavas

Basaltic Lavas

- Mid oceanic ridges
- Mafic in composition
- Higher temperature
- Rarely explosive

A central vent eruption from Kilauea, Hawaii produces fast flowing Basaltic lavas

Type of Basaltic Lavas

Pillow Lava

Andesitic Lavas

- Intermediate SiO_2
- Flow relatively slow
- Temperature lower
- Subduction settings
- Phreatic explosions

Mount St Helens, a andesitic volcano in south-western Washington state

Phreatic explosions

Rhyolitic Lavas

•High silica (~68%)

• Temperature lower (600-800)

•Thick bulbous deposits

•Gases are easily trapped with in ryholitic lavas

Viscous rhyolite lava flow. Wilson Butte dome, Long Valley, California

Textures of Volcanic rocks

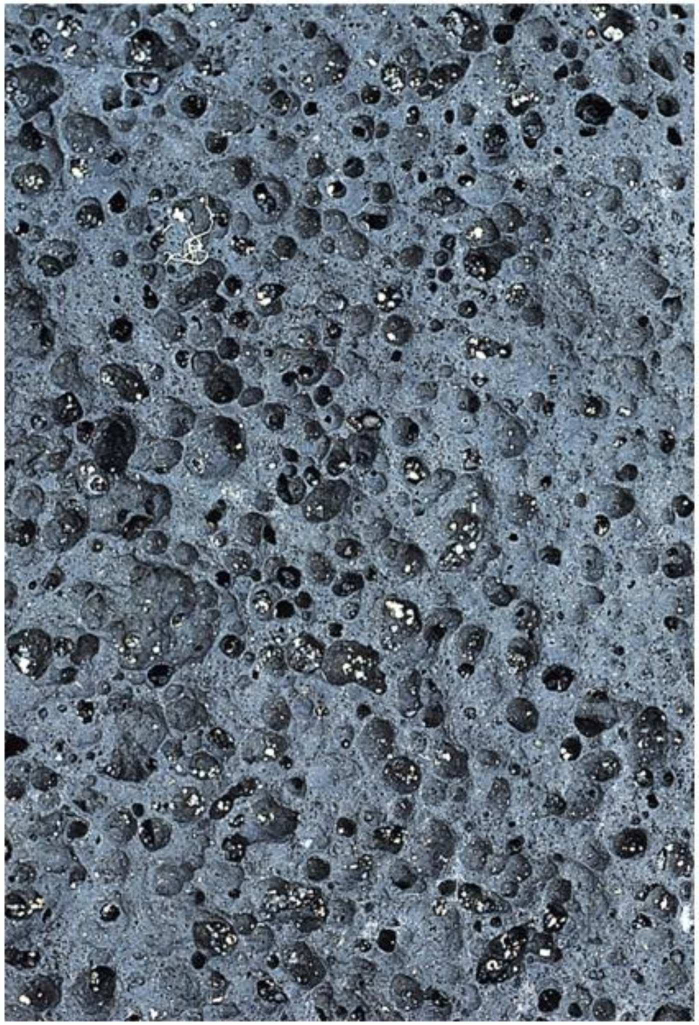
Obsidian

Vesicular

Obsidian

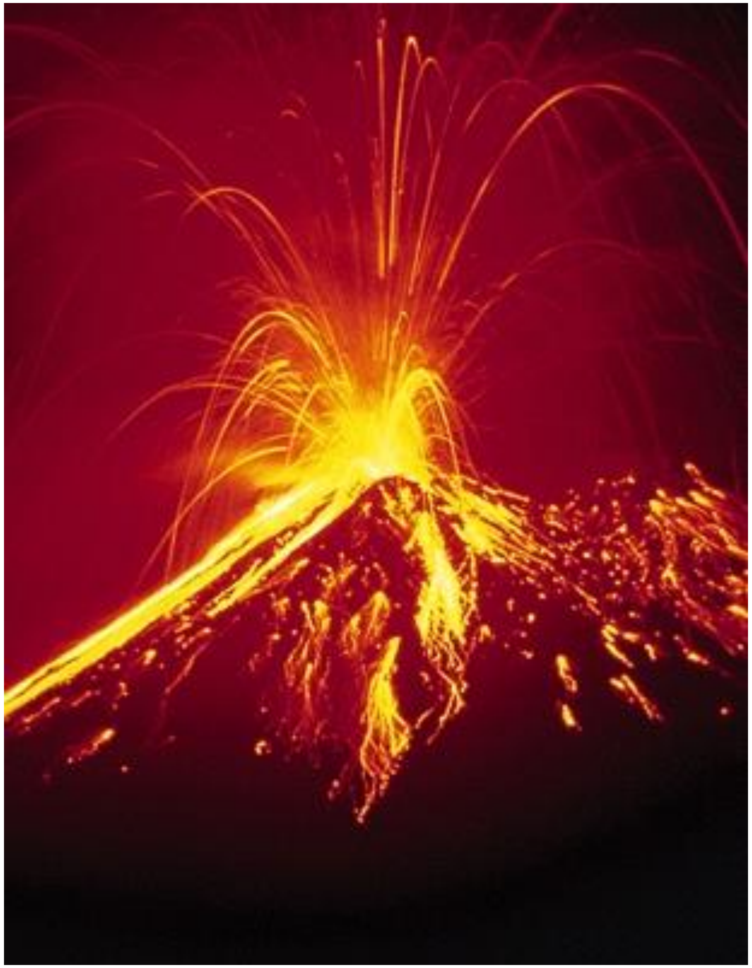
Silica rich rapidly cooled lavas form obsidian

Vesicular Basalt



Pumice floating in water

Pyroclastic deposits



Explosive eruption at Arenal Volcano, Costa Rica

Volcanic ejecta

Pyroclastic flows

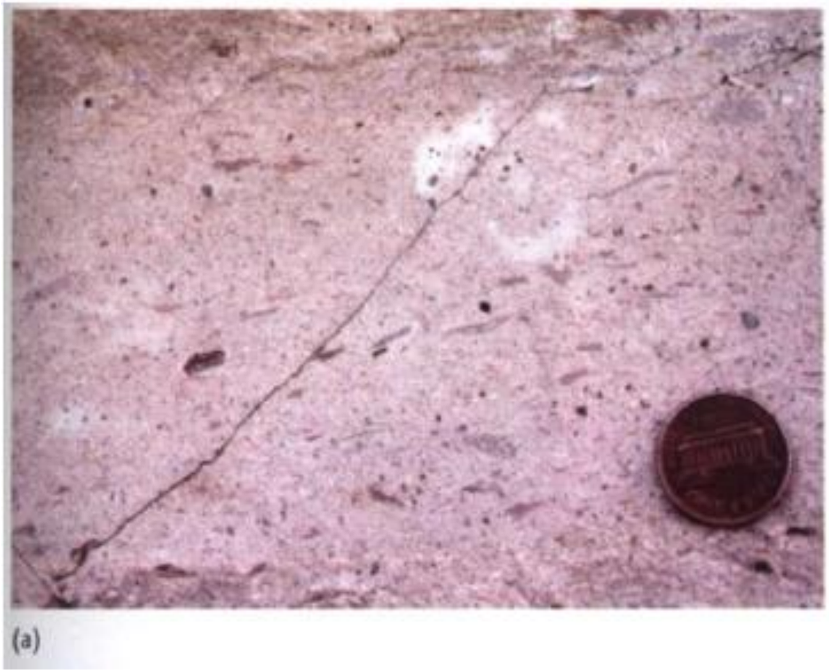
Pyroclastic deposits

- Volcanic ash – less than 2mm in diameter
- Volcanic Bombs- large fragments

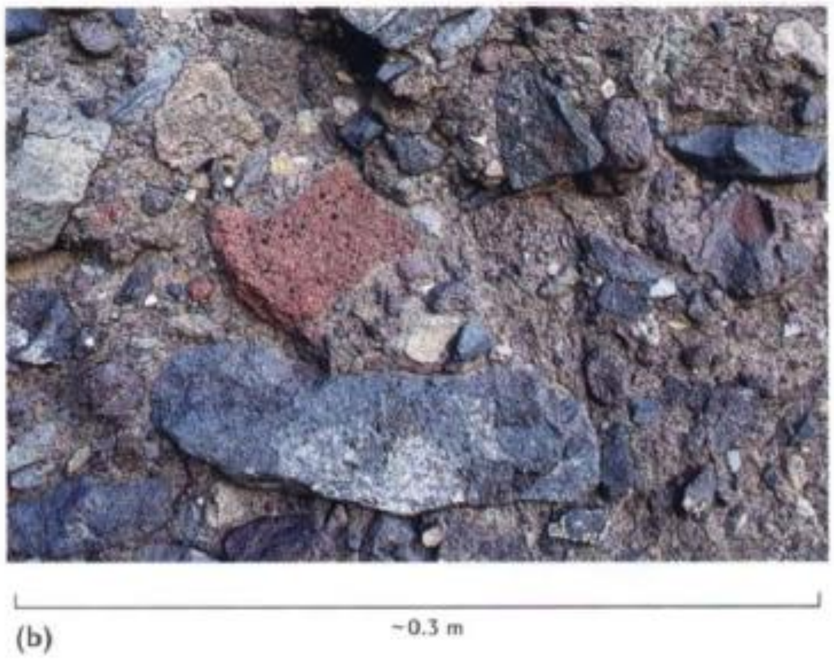
Volcanic ash

Volcanic Bombs

Pyroclastic deposits

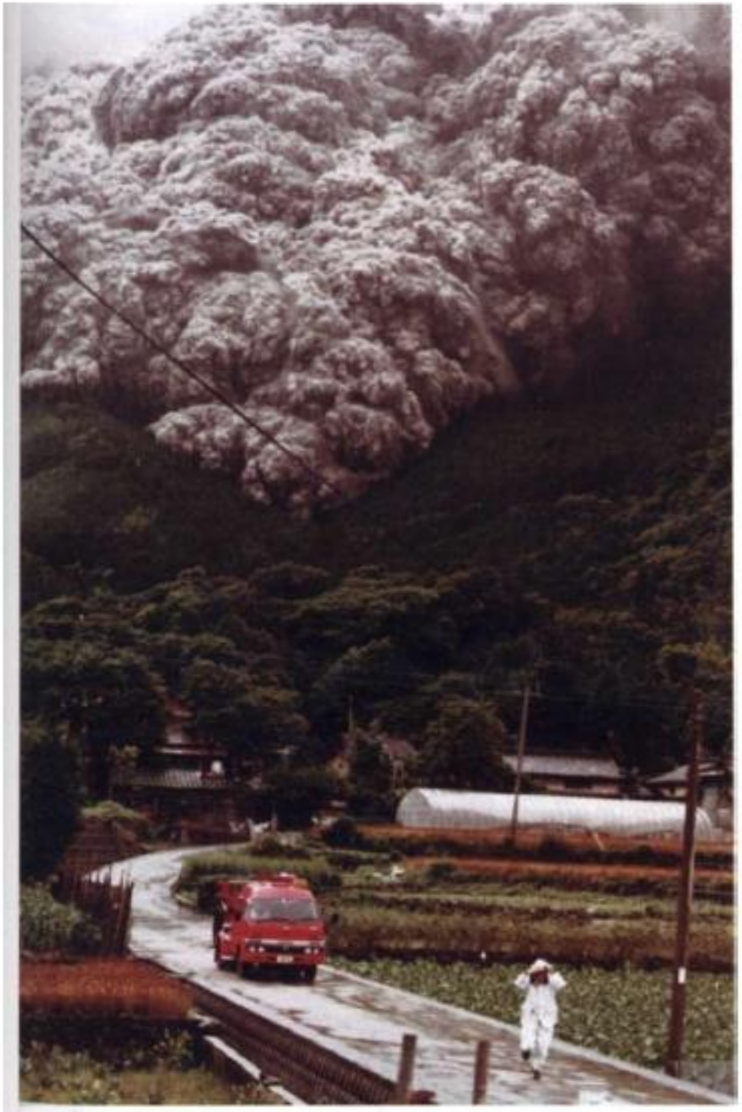


Tuff



Volcanic breccia

Pyroclastic flow



Pyroclastic flow plunged down the slopes of Mount Unzen, Japan

Eruptive styles and landforms

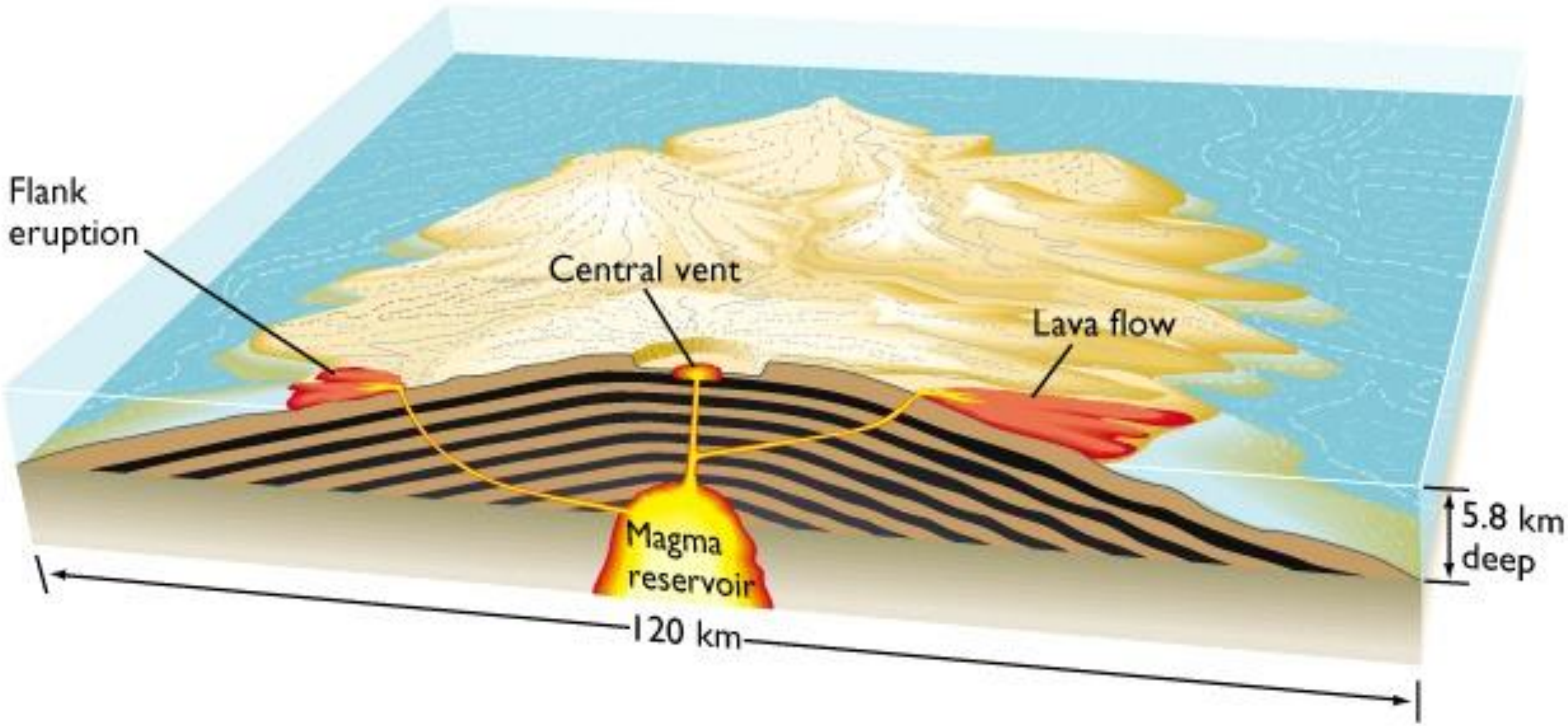
- **Composition of magma**
  - gas content
  - chemical compostion
- **Type of material erupted (lava versus pyroclasts)**
- **Environmental condition in which it erupts (submarine vs. continental)**

Central Eruptions

Shield Volcanoes

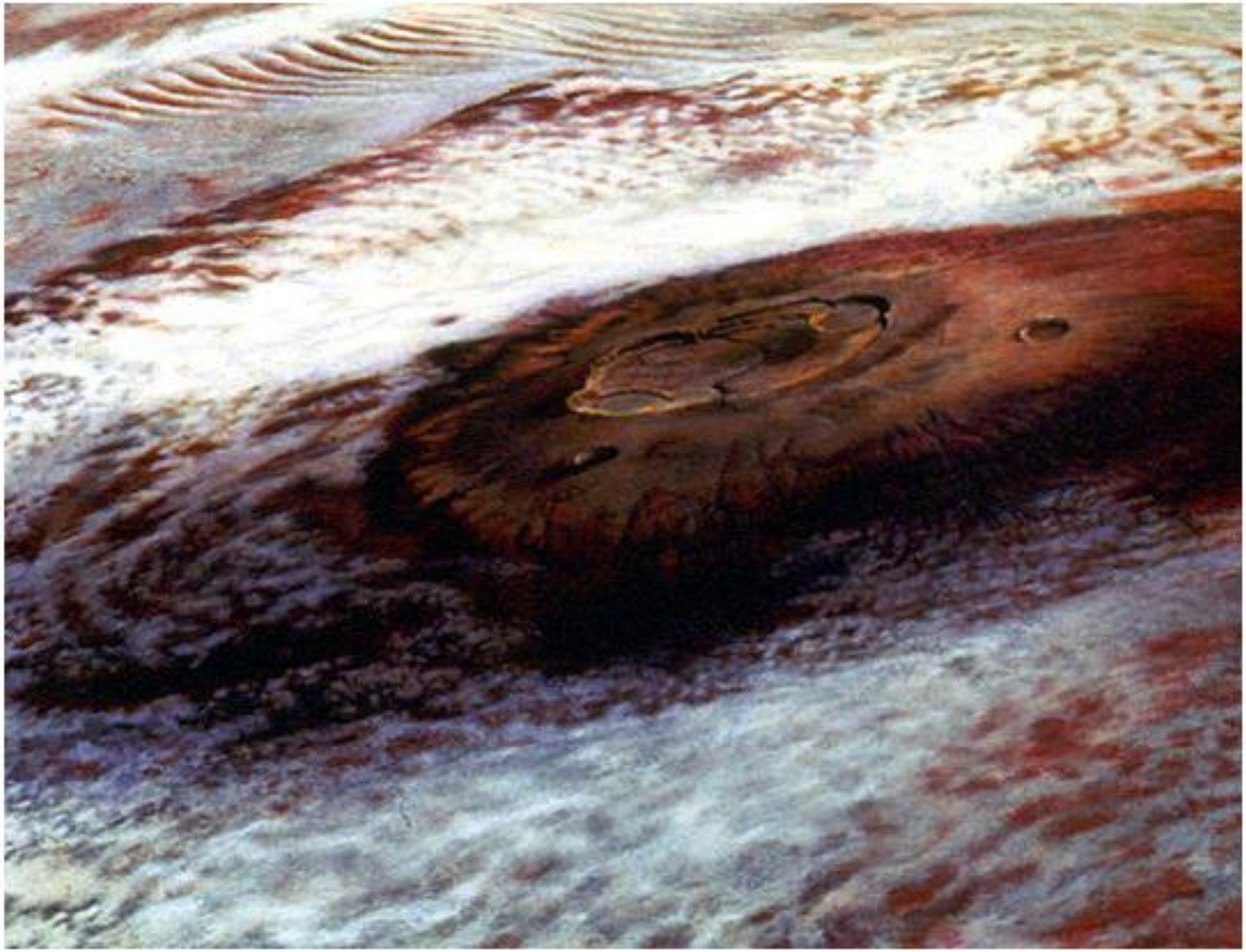
- **Low-viscosity lava flows (Mafic)**
- **Gently sloping flanks — between 2 and 10 degrees**

Shield Volcanoes



Shield Volcanoes

Olympus Mons Shield Volcano

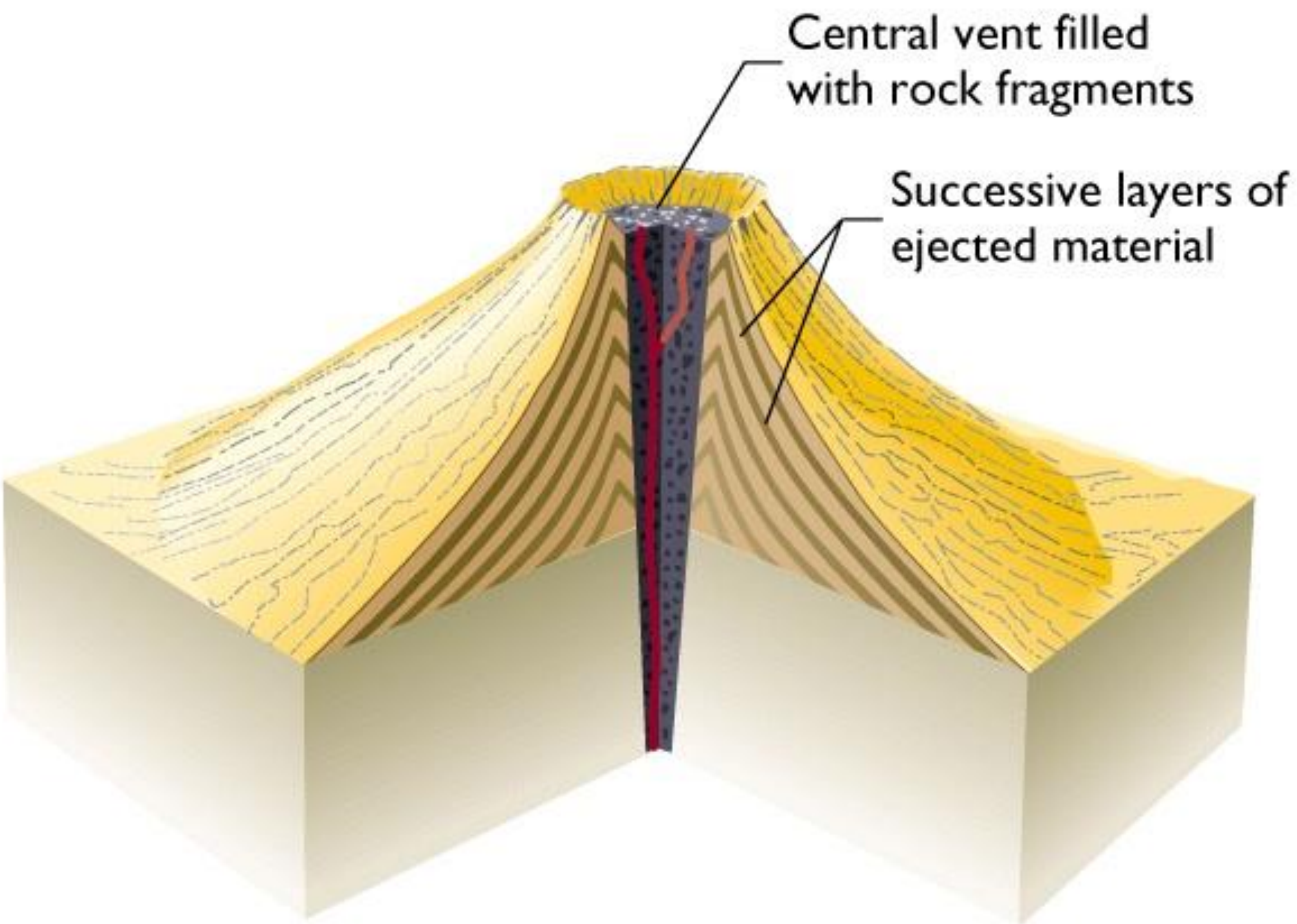


Central Eruptions

Cinder Cones

- **Formed of pyroclastics only**
- **Steep sides — ~30 degrees**
- **Short duration of activity**
- **Larger fragments near to vent form steep slopes**

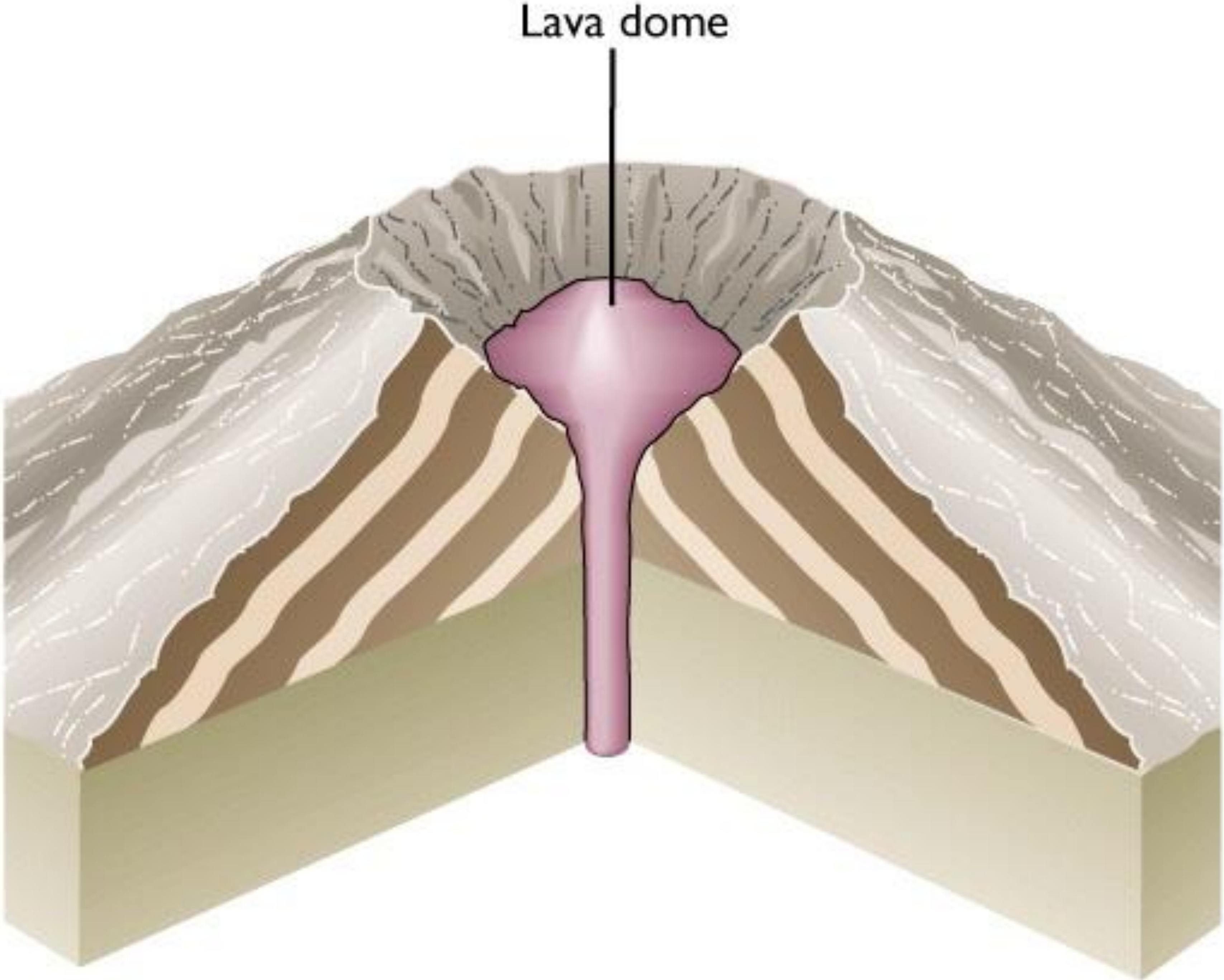
Cinder Cones



Cerro Negro Cinder Cone near Managua Nicaragua in 1968

Volcanic domes

- **Forms above a volcanic vent, a bulbous step sided mass of rock**
- **Viscous lava — usually silica-rich (or cooler magma)**
- **Associated with violent eruptions**


Lava dome

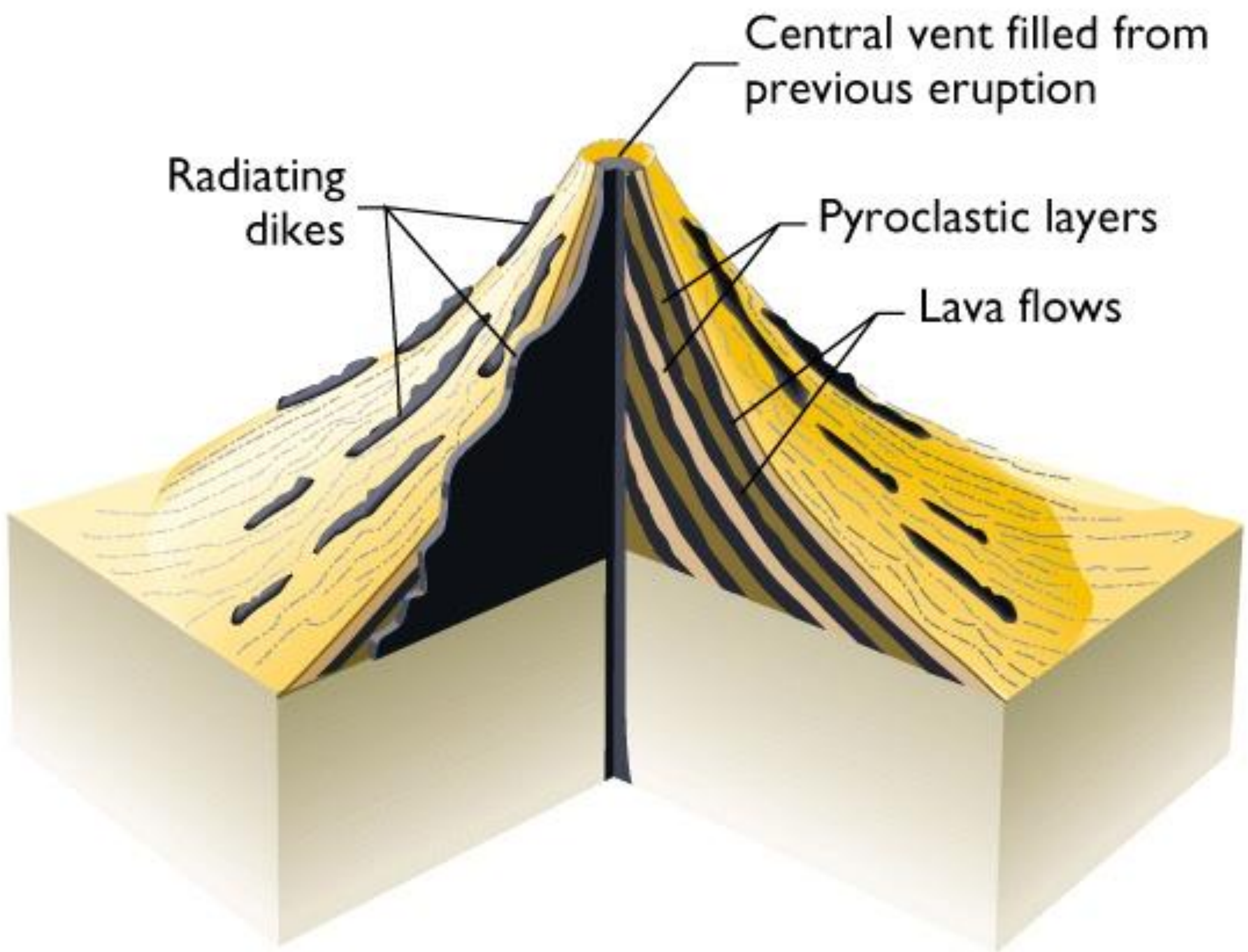
Lava
Dome

INYO OBSIDIAN DOMES-CALIFORNIA

Composite/strato Volcano

- **Alternating pyroclastic layers and lava flows**
- **Slopes intermediate in steepness**
- **Intermittent eruptions over long time span**
- **Mostly *Andesite***
- **Distribution**
  - Circum-Pacific Belt (“Ring of Fire”)
  - Mediterranean Belt

Composite Volcano



MT FUJIYAMA, JAPAN

Fig. 5.15

Crater

- Bowl shape pit found at the summit of volcanic mountains

Xico volcanic crater, Mexico city

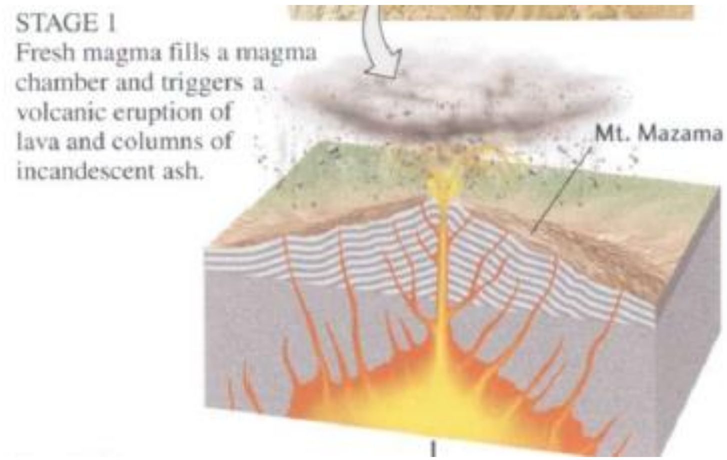
Calderas

- Depression at top of volcano produced during an eruption

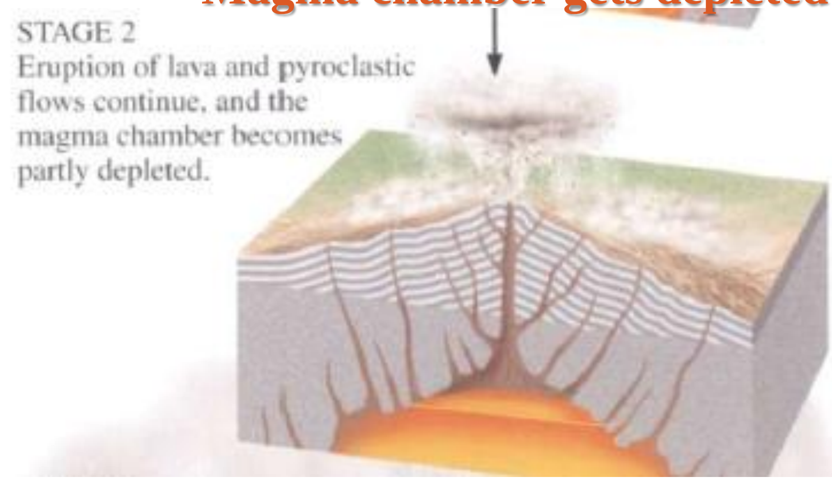
- Great volume of magma are discharged rapidly from a large magma chamber, the chamber can no longer support it

Calderas

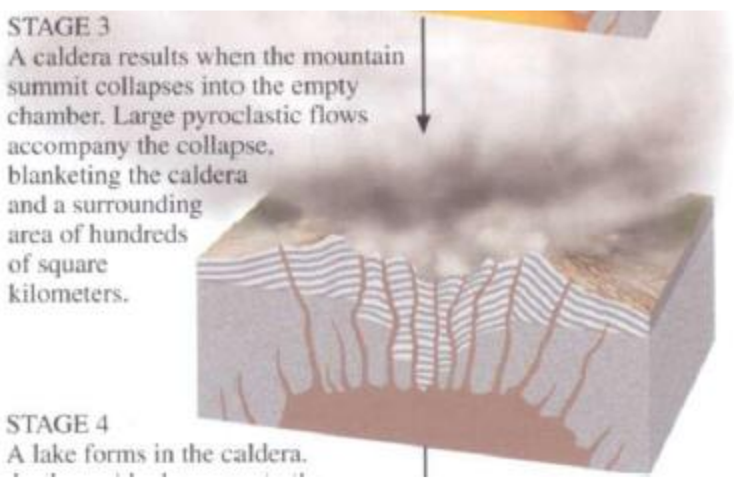
Volcanic eruption

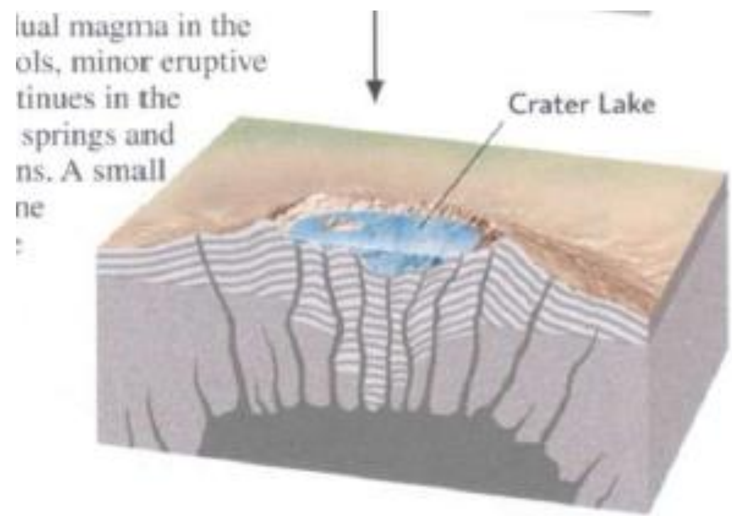


Magma chamber gets depleted



Collapse of mountain summit into empty chamber

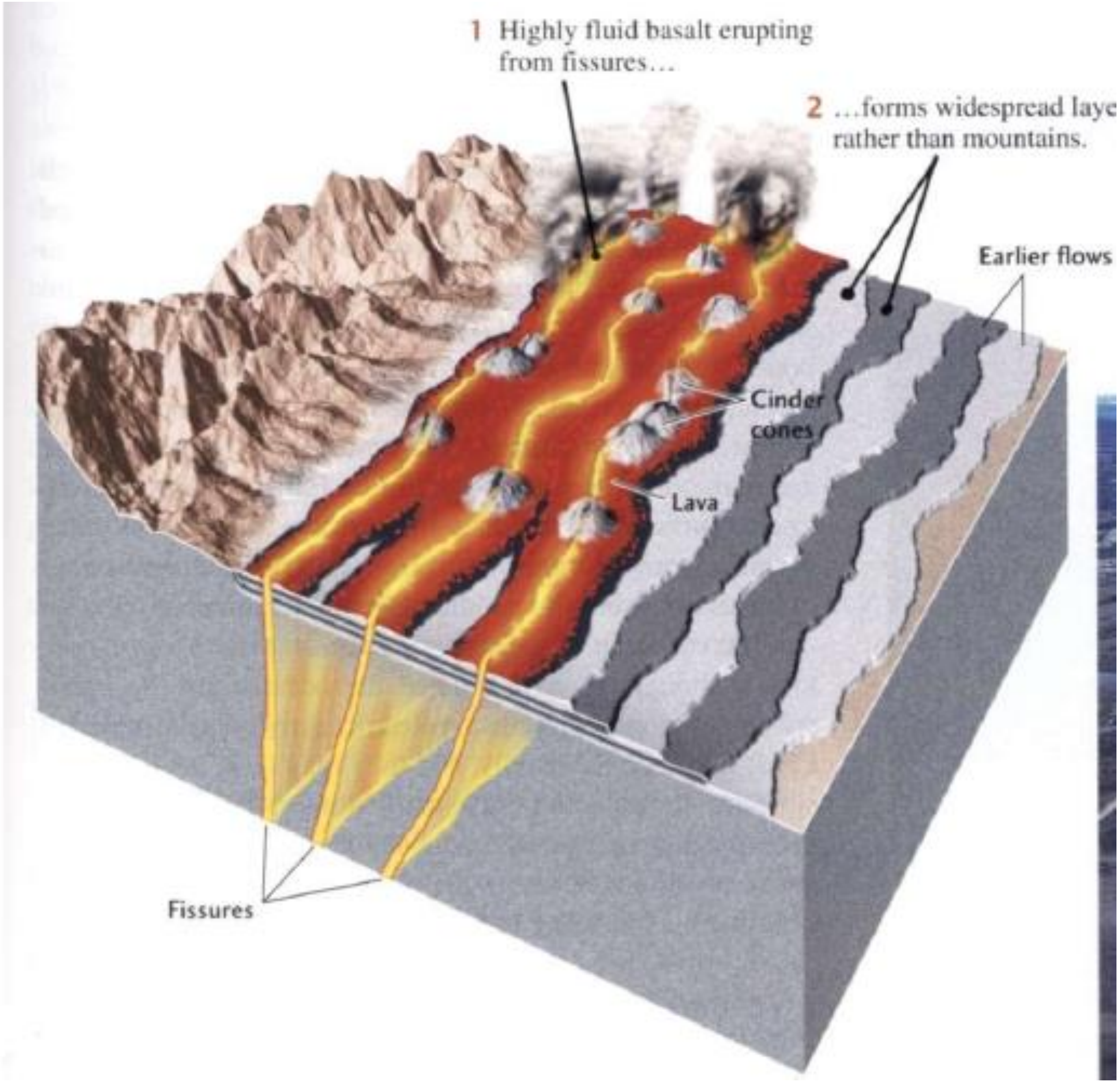




Mt Fujiyama, Japan   Before May, 1980


After May, 1980
David Weintraub/Photo Researchers

Fissure type eruption



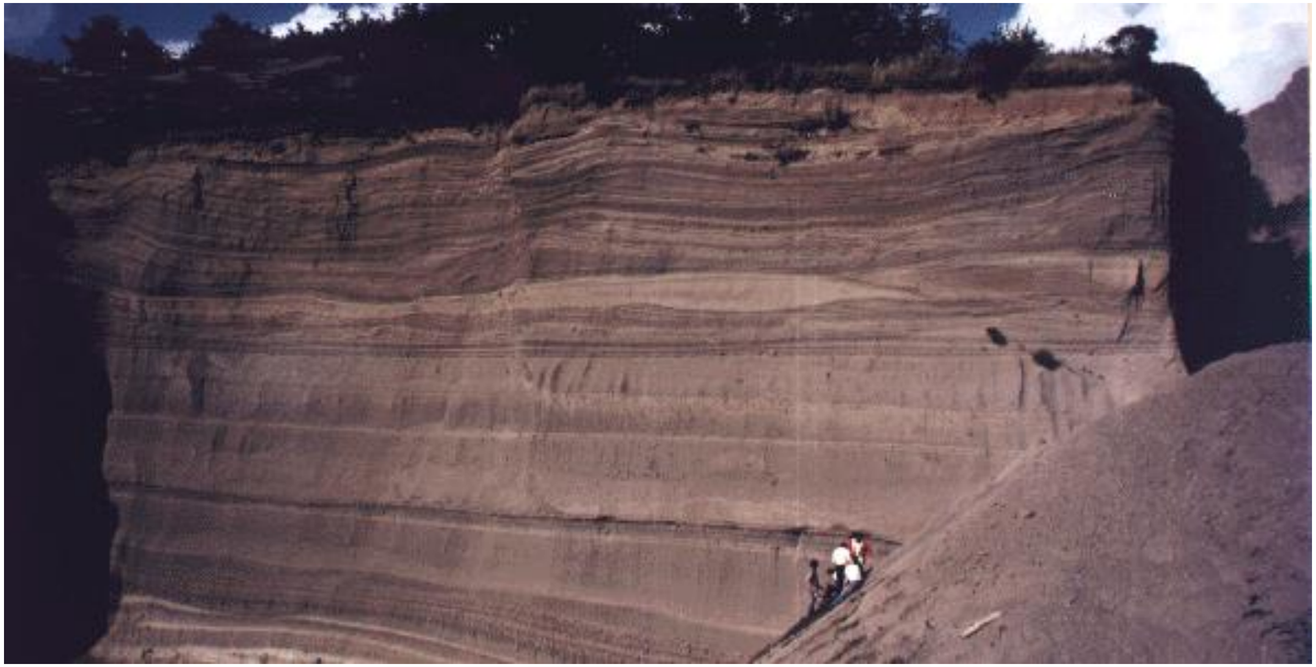
Fissure type eruption

Flood basalts

Deccan basalts

Fissure type eruption

Ash flow deposits



Quarry within pyroclastic deposits of Laacher See volcano, Germany

Materials ejected from Volcanoes

Volatile material

- **Steam (H_2O)**
- **Carbon dioxide (CO_2)**
- **Hydrogen sulfide (H_2S)**
- **Many other constituents (N, Ar, He etc)**

Sulfur-encrusted fumerole: Galapagos Islands

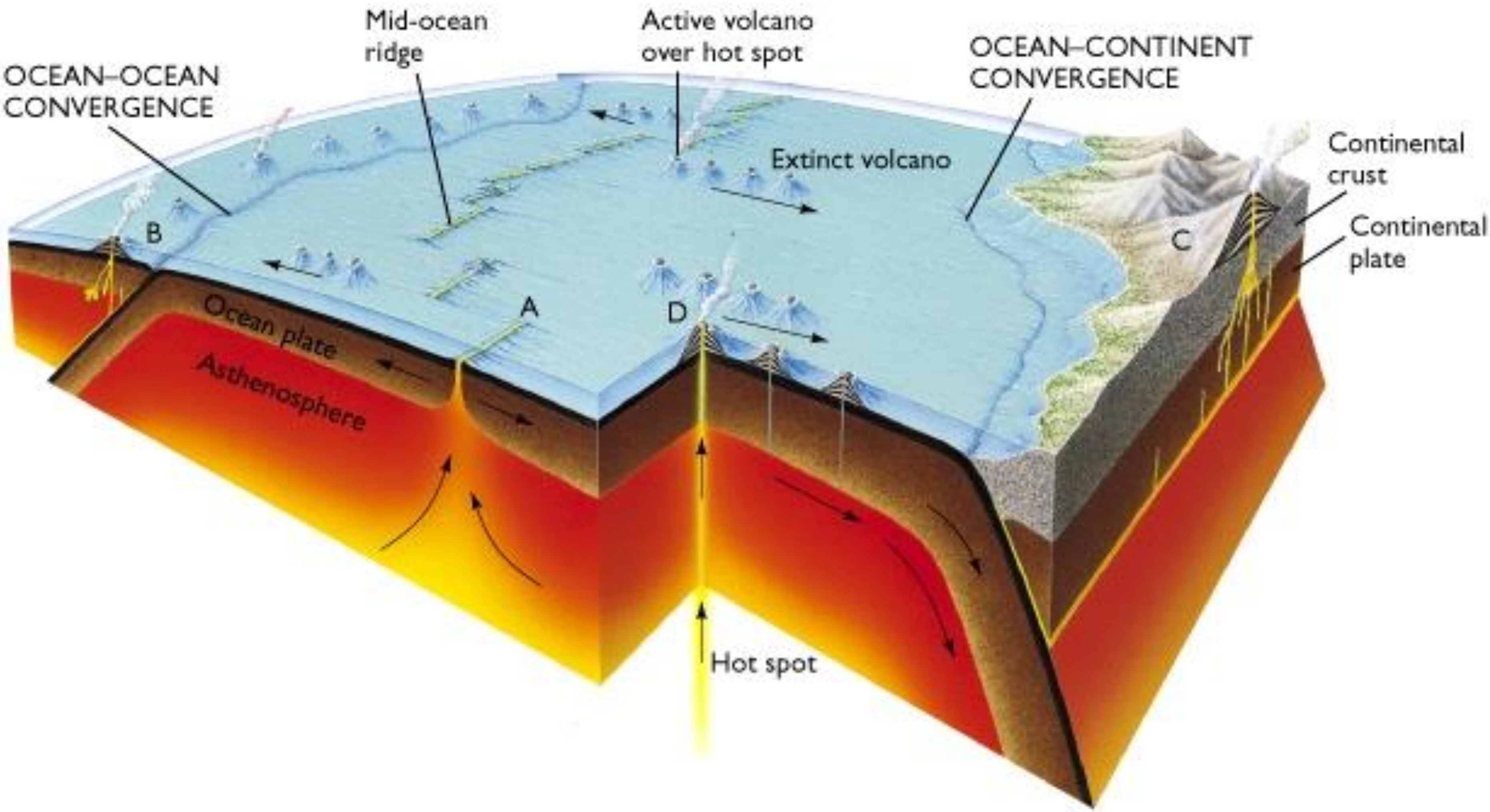
The tectonic setting of Volcanoes

- Convergent plate boundaries

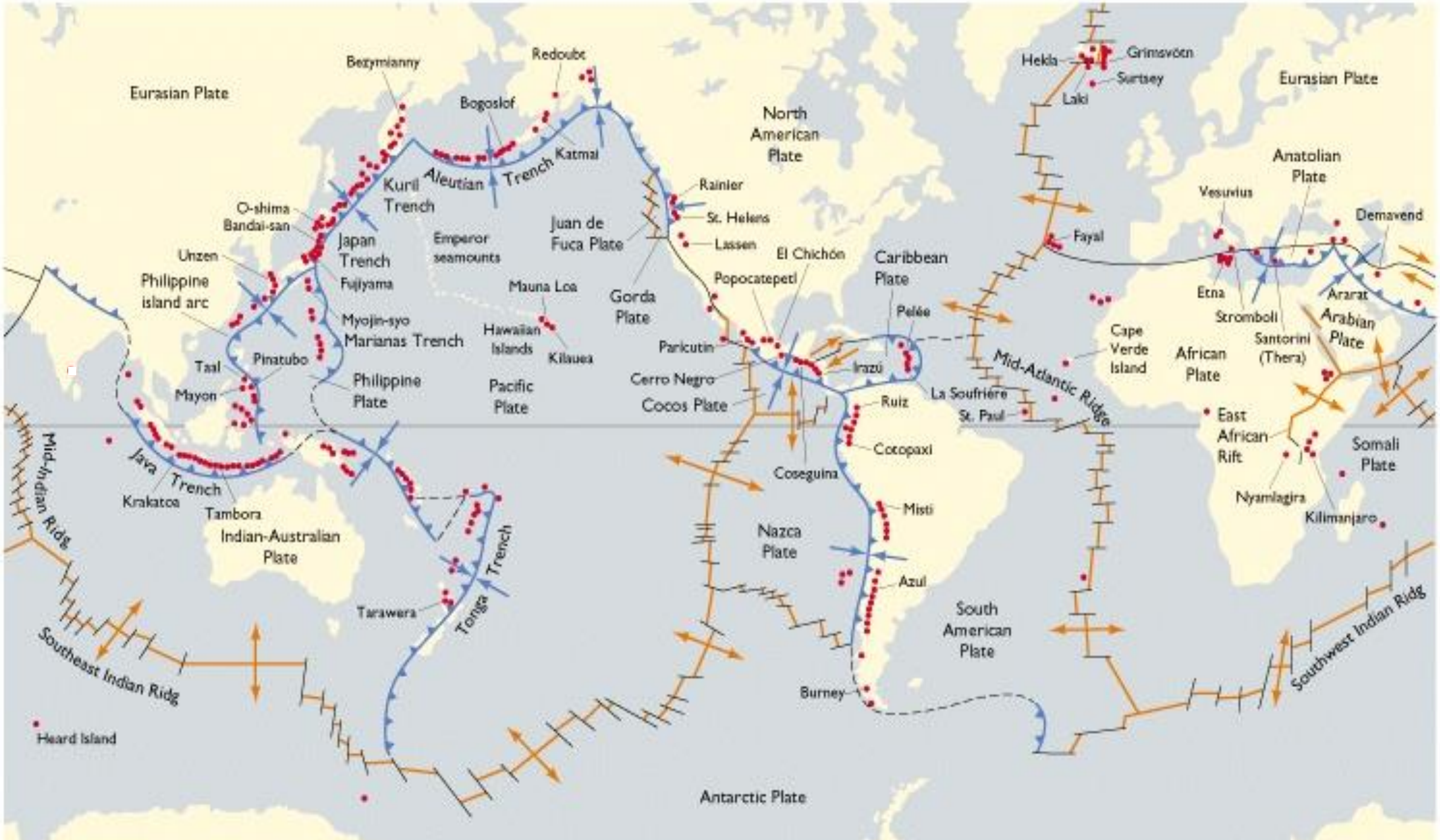
- Divergent plate boundaries

- Within plate “hotspots”

The Volcanism associated with plate tectonics

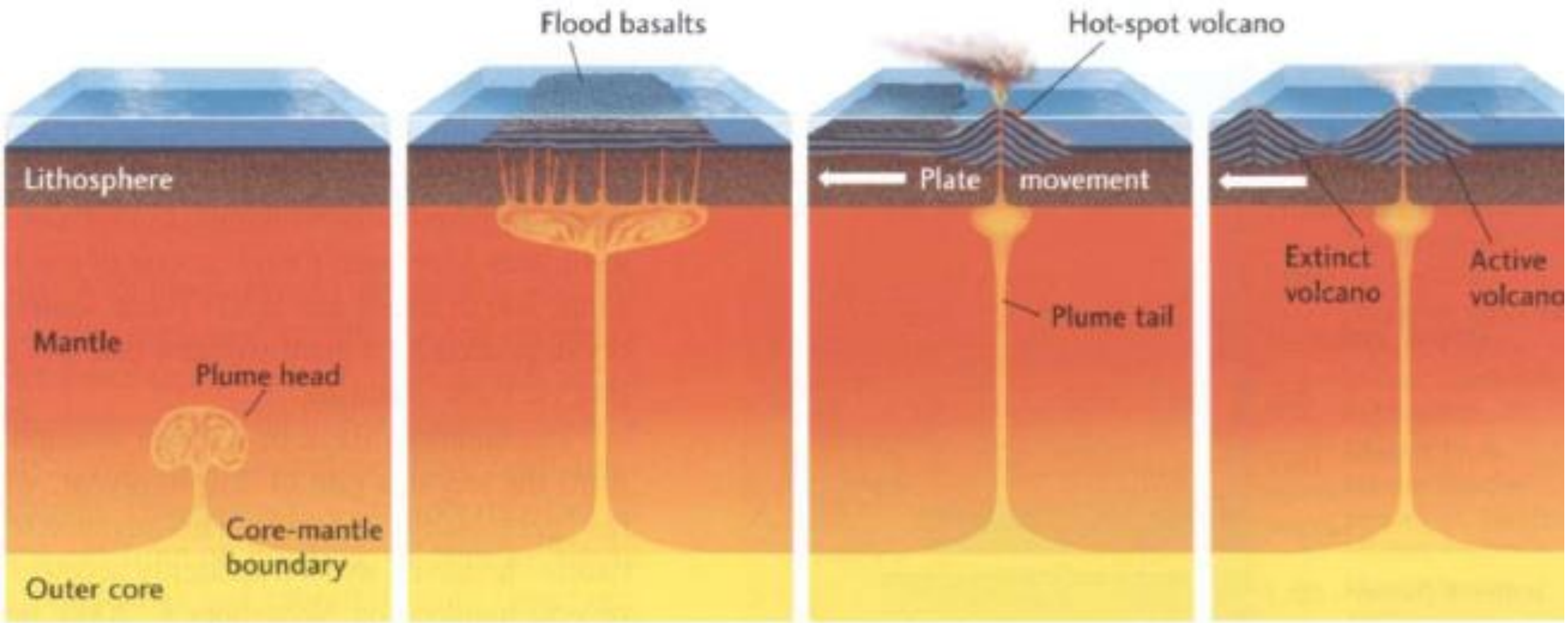


The world`s active Volcanoes



Hotspots/Mantle plumes

- Arises in the core mantle boundary
- Large turbulent blob of hot materials- ‘plume head’
- At top of the mantle the plume head generates large amount of magma



Speculative model for the formation of Hot spots