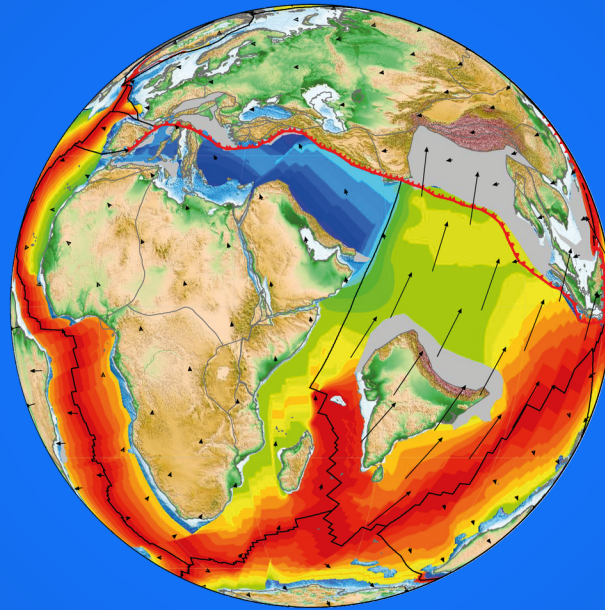


# Plate Tectonics



*Part II*

# On this date...



Fridtjof Nansen  
Born October 10, 1861

early oceanographer, explorer, humanitarian

# Recap of Last Week

- Earth structure: stratified by density:
  - Lithosphere < Aesthenosphere < Mantle < Core
- Fluid motion in the mantle
- Convection cells
- Connections between continents
- Supercontinents
  - more than one occurrence
  - Pangea was recent

# In the news...

## SCIENTIFIC REPORTS


OPEN

### Tip-dated phylogeny of whirligig beetles reveals ancient lineage surviving on Madagascar

Received: 14 June 2017

Accepted: 11 July 2017

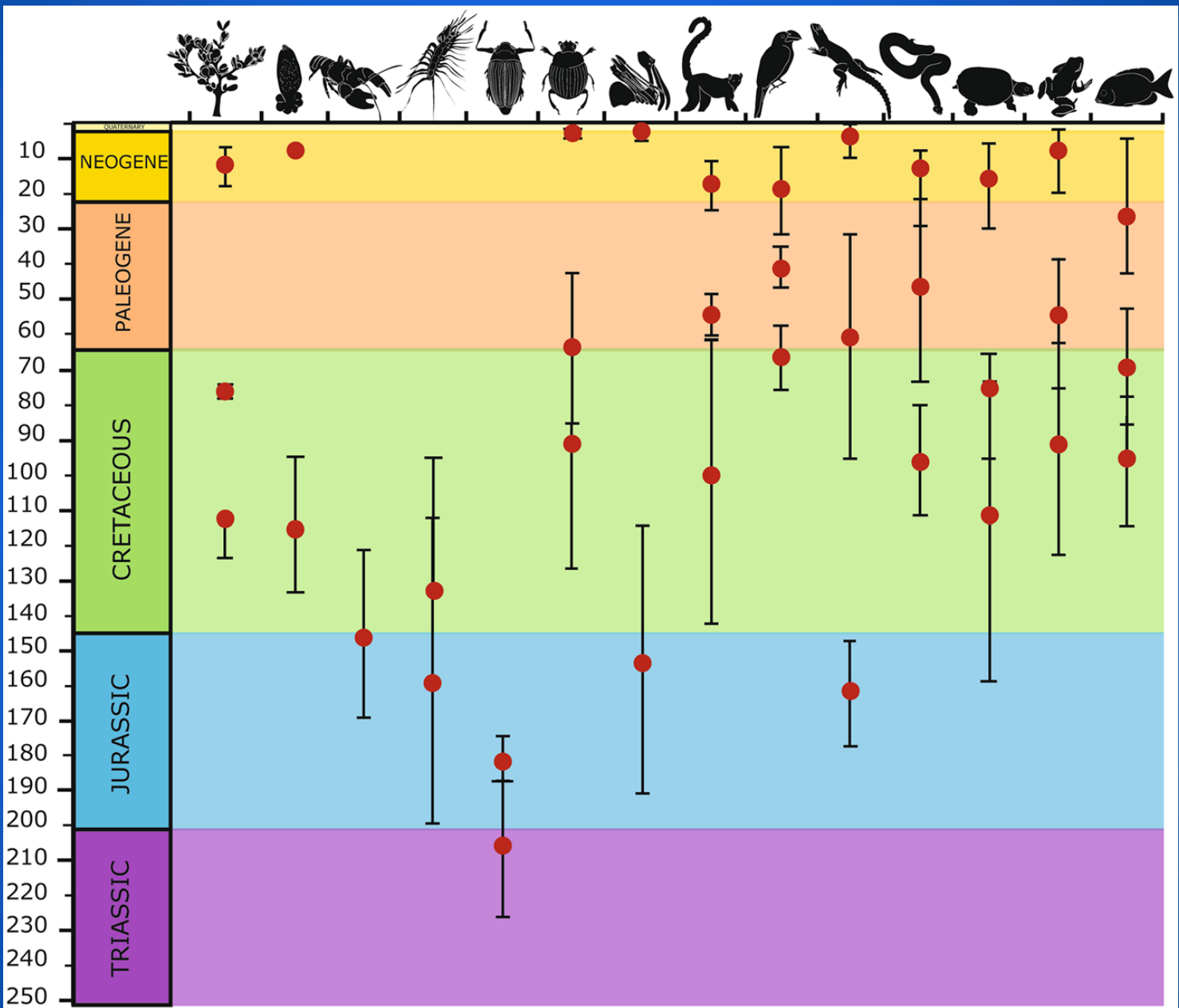
Published online: 22 August 2017

Grey T. Gustafson <sup>1</sup>, Alexander A. Prokin<sup>2</sup>, Rasa Bukontaite<sup>3</sup>, Johannes Bergsten<sup>3</sup> & Kelly B. Miller<sup>4</sup>

The temporal origin of Madagascar's extraordinary endemic diversity is debated. A preference for Cenozoic dispersal origins has replaced the classical view of Mesozoic vicariance in the wake of molecular dating. However, evidence of ancient origins is mounting from arthropod groups. Using phylogenetic 'tip-dating' analysis with fossils, we show that a whirligig beetle species, *Heterogyrus milloti*, inhabiting forest streams in southeastern Madagascar is the last survivor of a once dominant and widespread Mesozoic group. With a Late Triassic to Early Jurassic origin (226–187 Ma) it is the hitherto oldest dated endemic lineage of animal or plant on Madagascar. Island biotas' sensitivity to extinction is well known, but islands can also provide refuge from continental extinction. *Heterogyrus milloti* is an irreplaceable link to the freshwater biota of the Mesozoic and serves as a reminder of what may be lost without critical conservation efforts on Madagascar.

<https://www.sciencedaily.com/releases/2017/10/171004140125.htm>







# Evidence Supporting Wegener's Continental Drift

The theory of continental drift was not accepted initially. Supporting evidence includes:

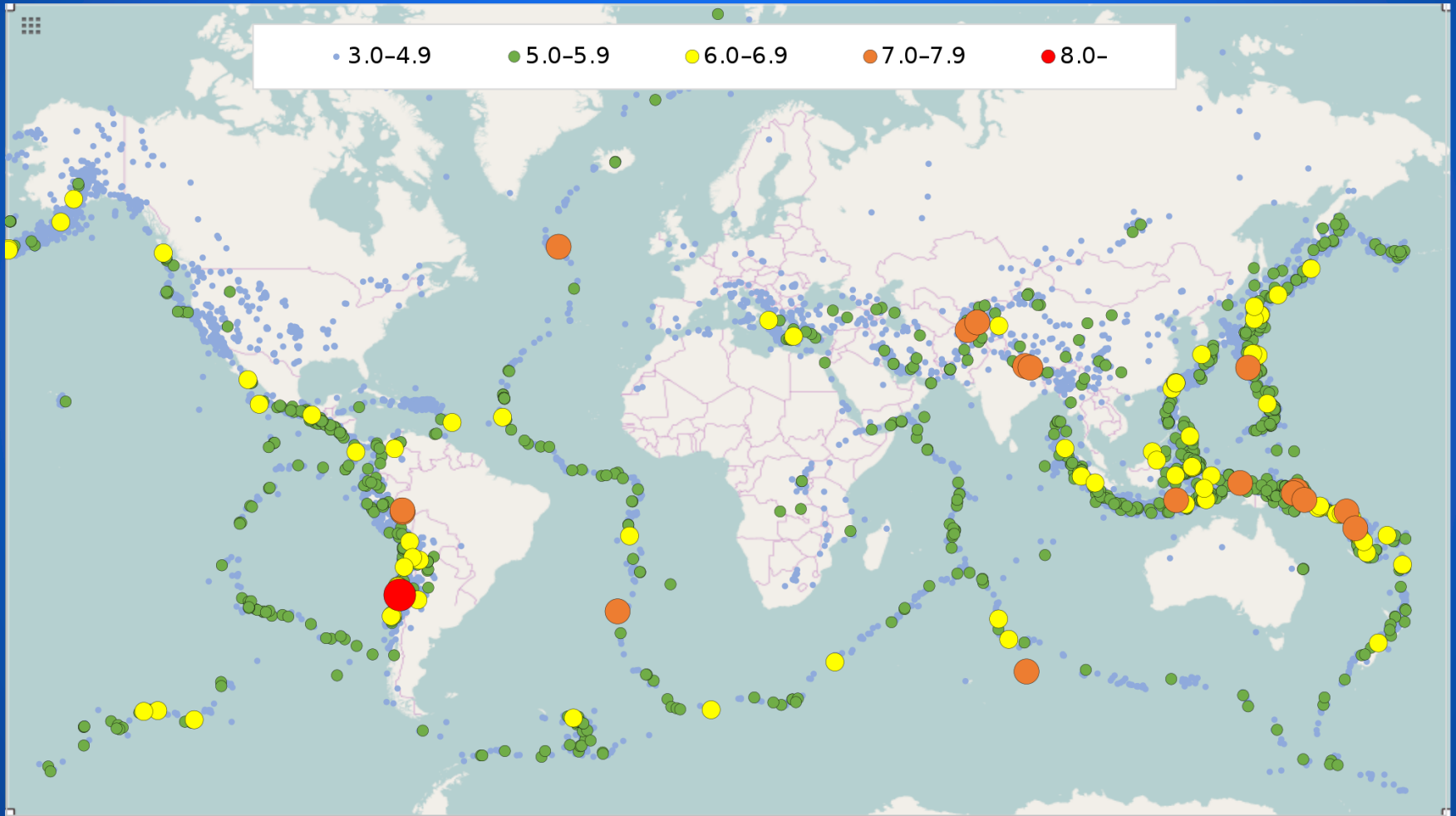
- **Seismographs** revealed a pattern of volcanoes and earthquakes bordering continents
- **Radiometric dating** of rocks revealed a surprisingly young oceanic crust
- **Echo sounders** revealed the shape of the Mid-Atlantic Ridge

# Problems with Drift Theory

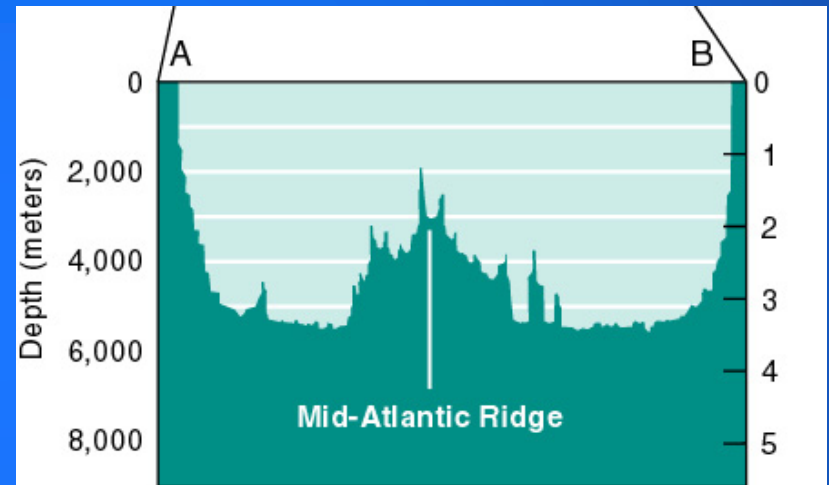
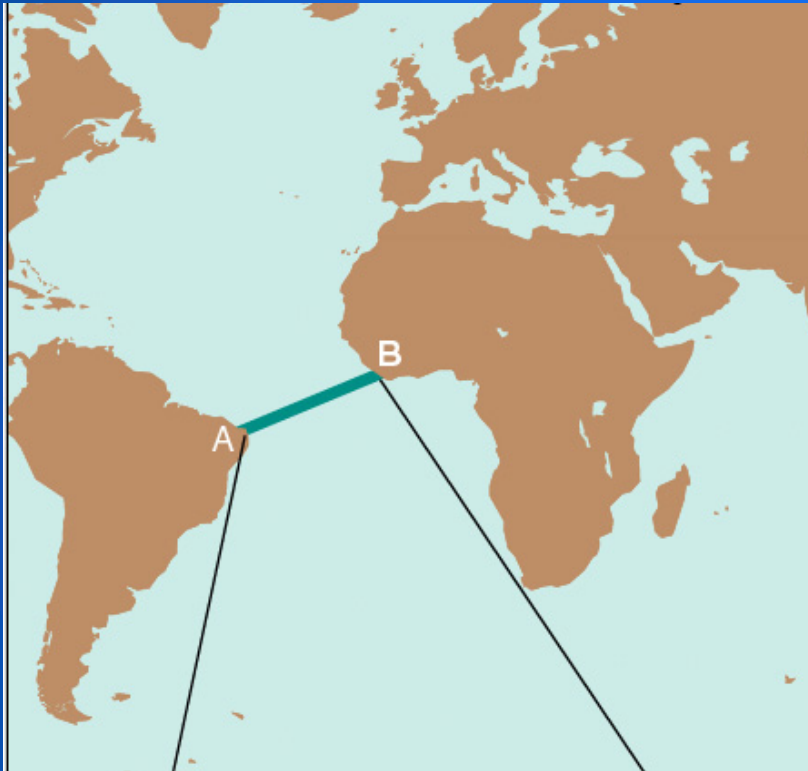
- No evidence for dramatic movement of the continents (tracks)
- Unfounded mechanism (centrifugation)
- Prevailing concept: solid mantle



# Seismographs



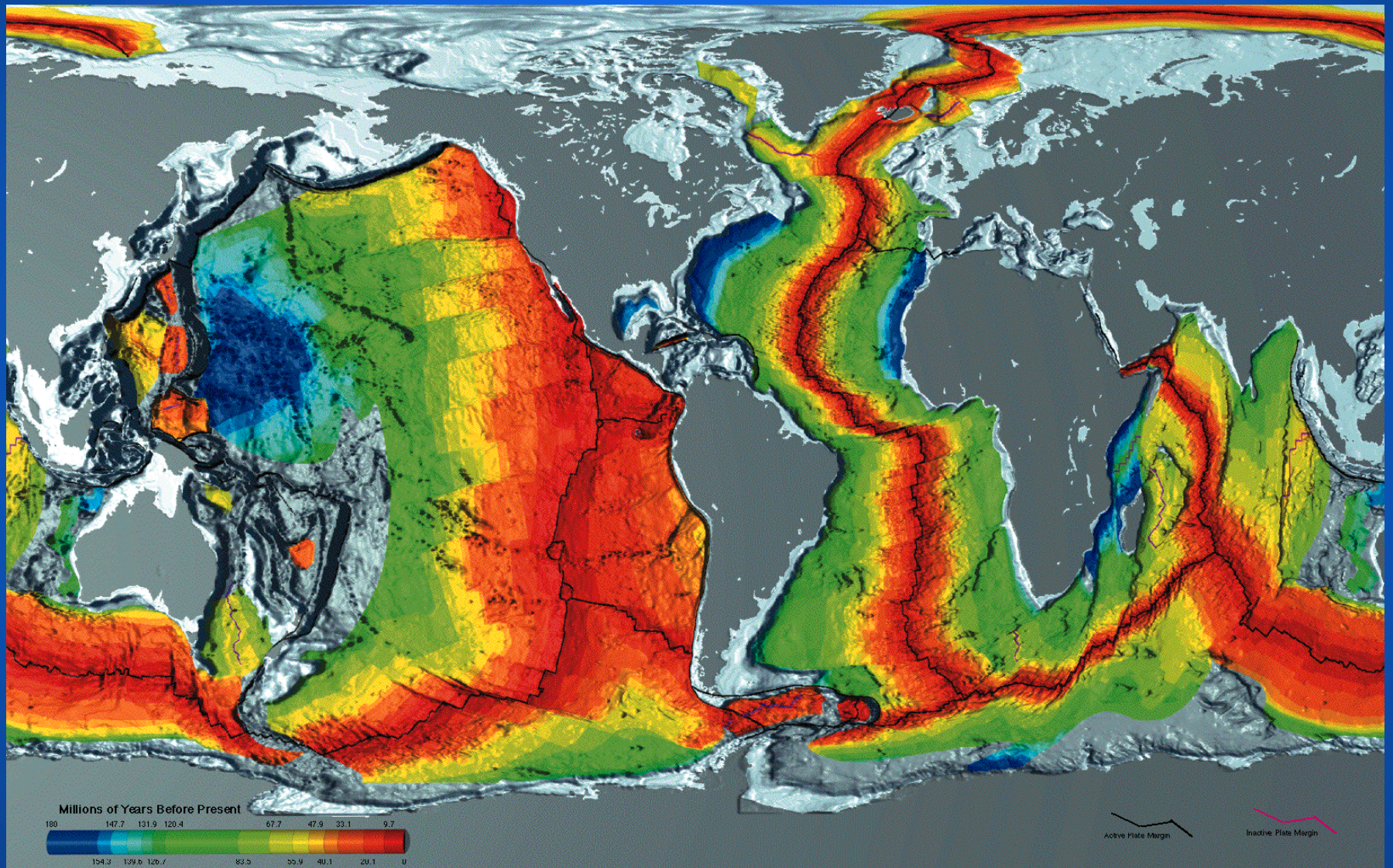
# Seafloor Topography



*A typical cross section of the Atlantic ocean basin*



# Seafloor Spreading





# The Seafloor





# The Seafloor

In the center of the Atlantic we find which of the following?

- A) Oceanic subduction zone
- B) The oldest oceanic crust
- C) The youngest continental crust
- D) Mid-atlantic ridge

# Hess and Deitz: **Seafloor Spreading** (1960)

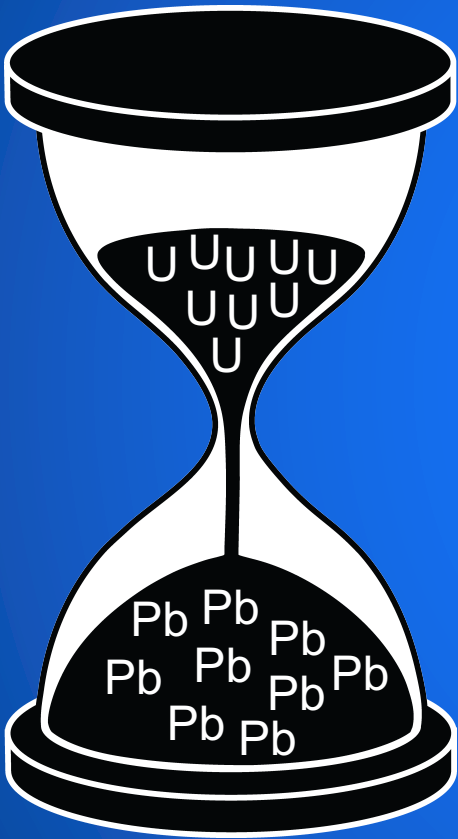
Seafloor forms at **mid-ocean ridges** and spreads

Powered by **convection currents**

Cooling and shrinkage of crust/ocean depth

Sediment thickness and ***age...***

# Radiometric Dating



- Radioactive decay of uranium to lead
- Complete conversion over billions of years
- U/Pb ratio tells age something formed
- Typically very old rocks: >0.1 Bya

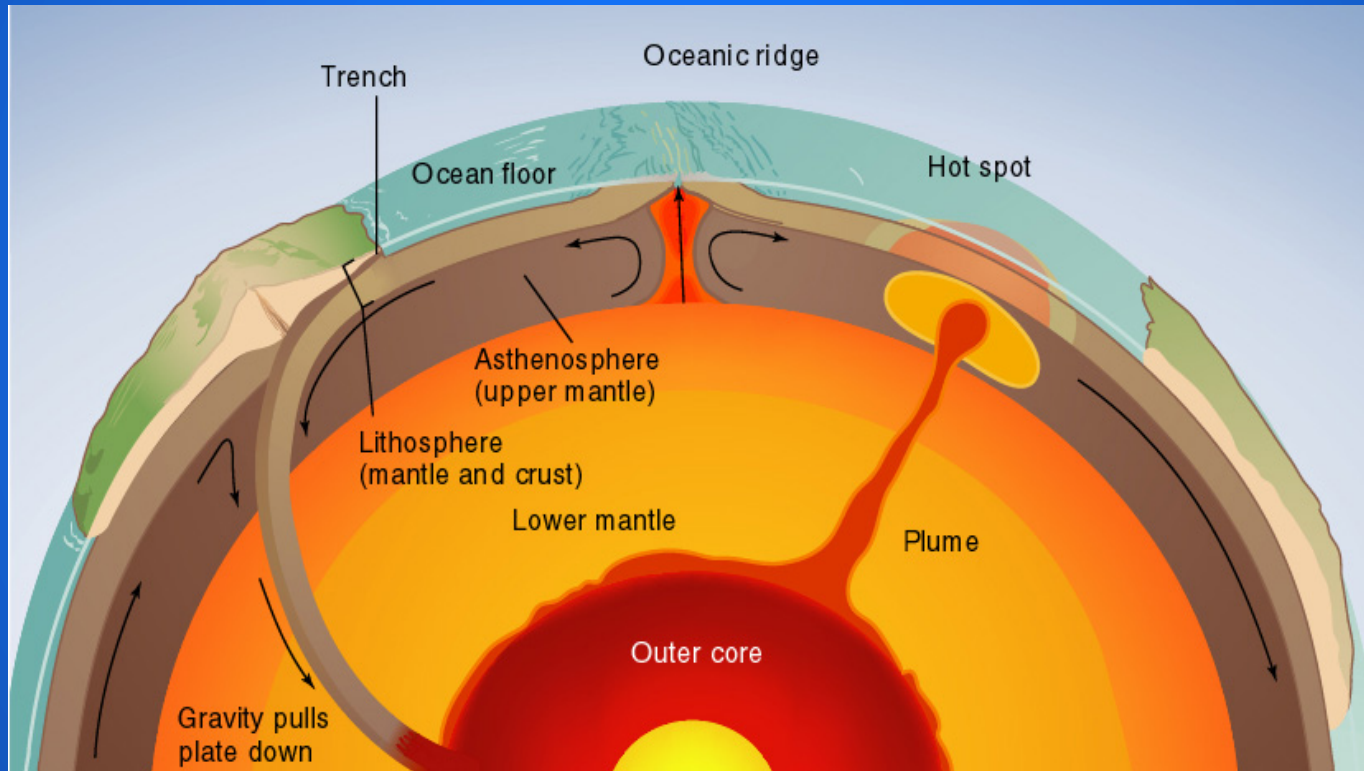
# The Theory Of Plate Tectonics

The ideas of **continental drift** and **seafloor spreading** were combined in the theory of **plate tectonics**:

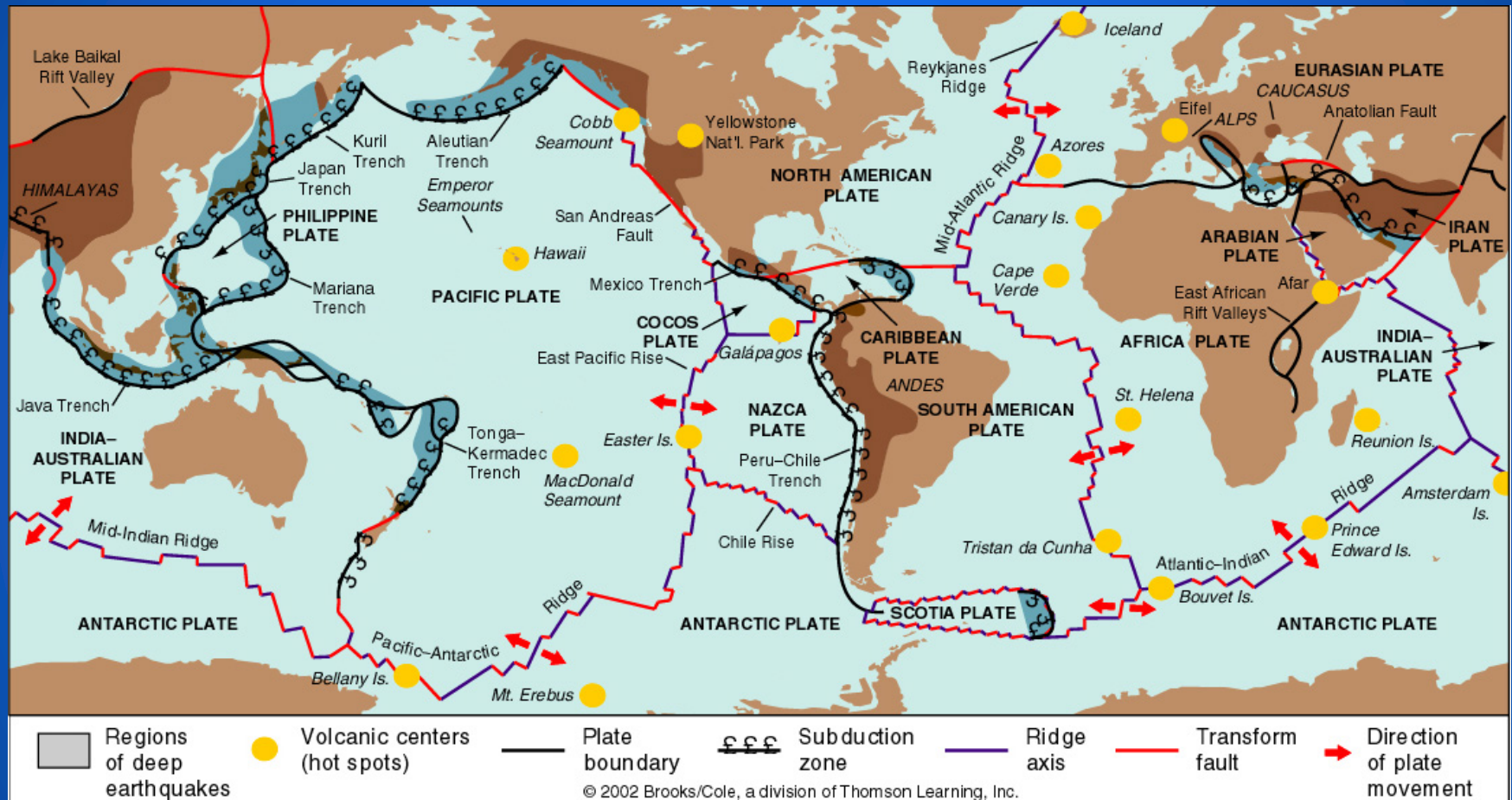
- Earth's outer layer is divided into lithospheric plates
- **Earth's plates float on the asthenosphere**
- Plate movement is powered by **convection currents in the asthenosphere**, seafloor spreading, and **subduction**



# Plate Tectonics



# The Major Lithospheric Plates

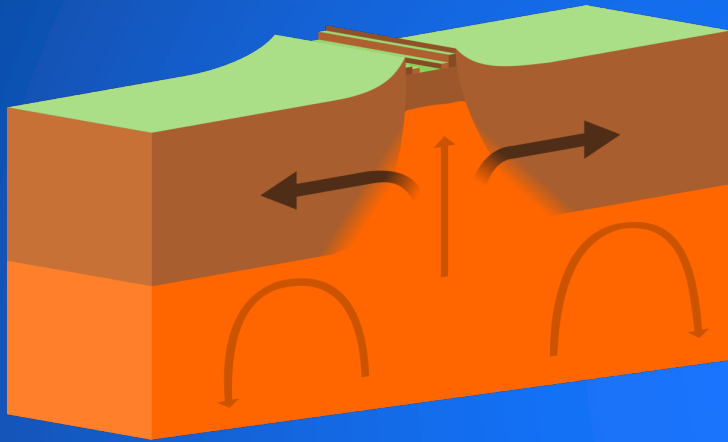


The major lithospheric plates and their direction of relative movement are shown here.

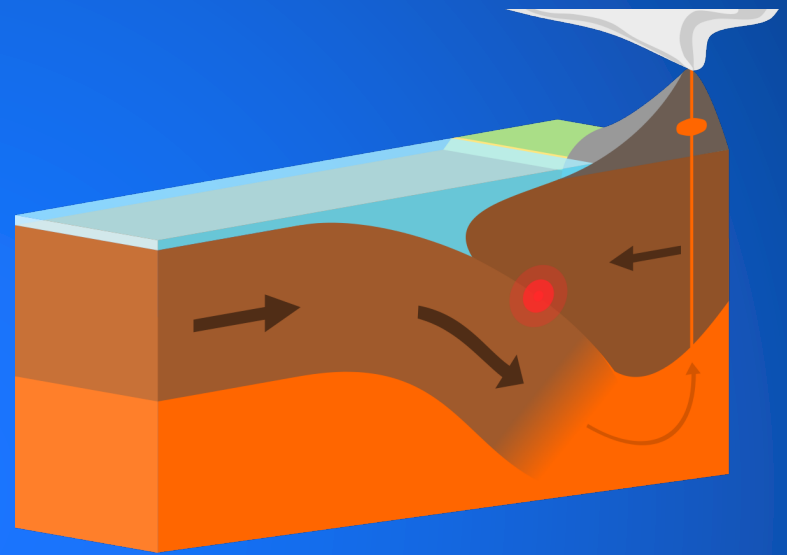
Which of the following is true of continental crust?

- A) During subduction, oceanic crust sinks below continental
- B) It is the oldest lithosphere and rarely subducts
- C) Continental crust meets at some plate boundaries
- D) All of the above

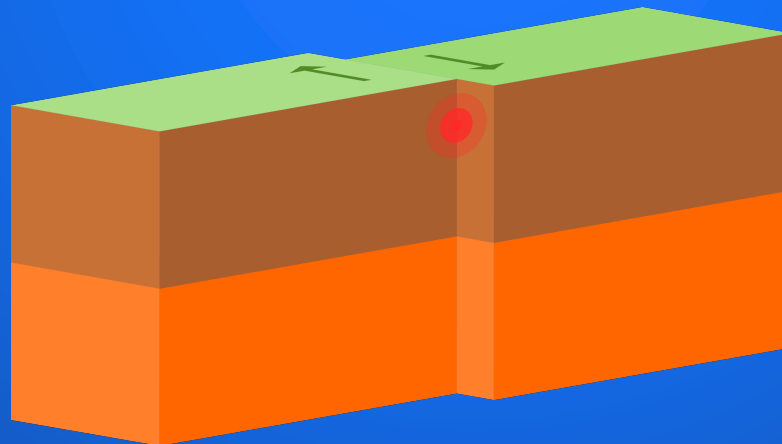
# Types of Plate Boundaries



*divergent / spreading*



*convergent / subduction*



*transform / “strike-slip”*

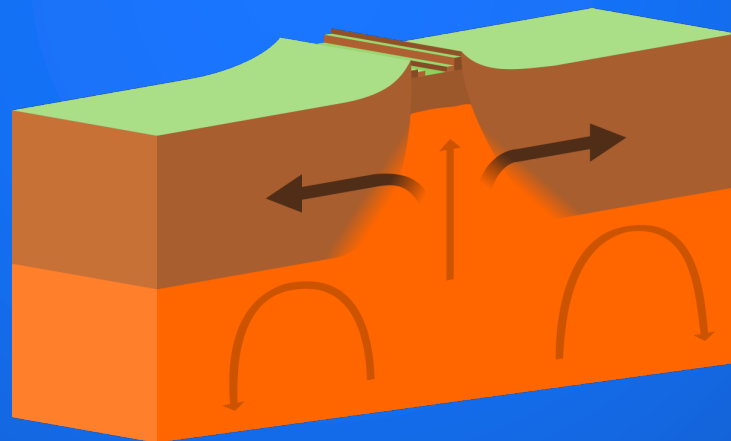


# Divergent Plate Boundaries

Boundaries between plates moving apart:

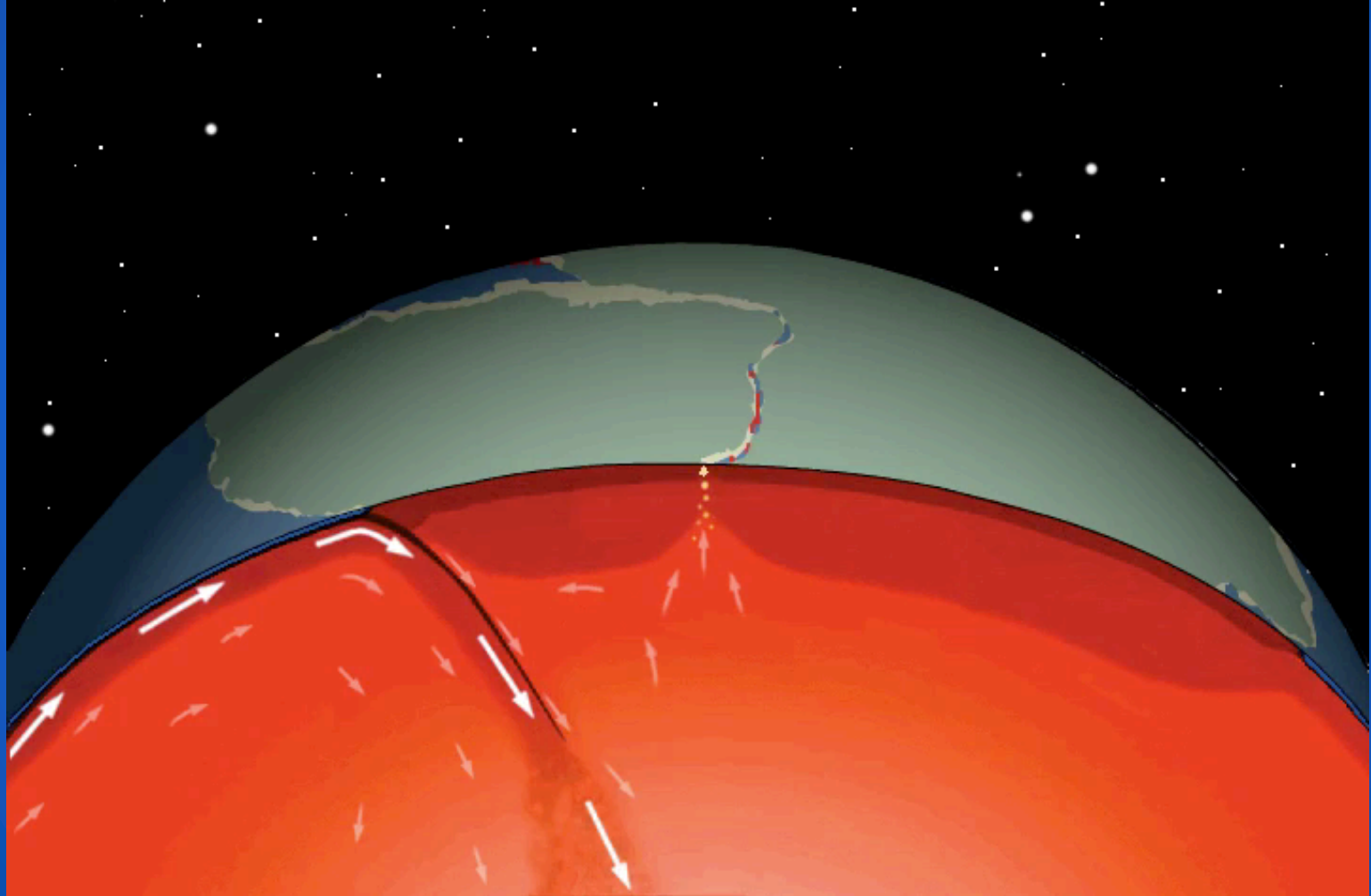
*Divergent oceanic crust* – e.g., the Mid-Atlantic Ridge

*Divergent continental crust* – e.g., Rift Valley of East Africa



*Extension causes splitting and rifting*

# Divergent Plate Boundaries



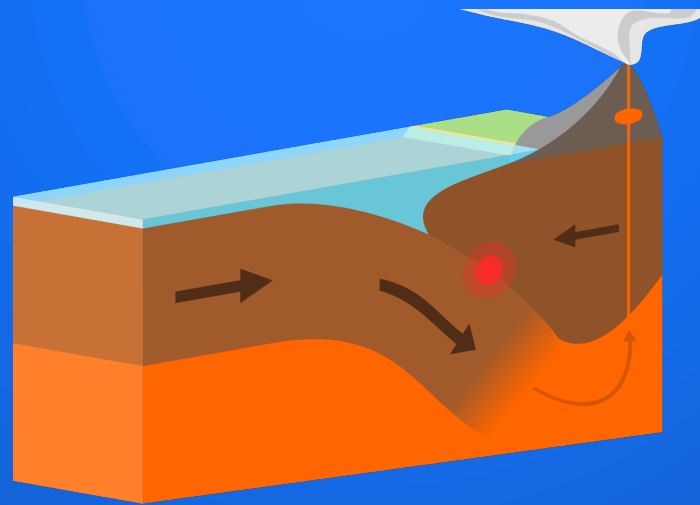
# Convergent Plate Boundaries

Regions where plates are pushing together:

*Oceanic crust toward continental crust - e.g., west coast of South America*

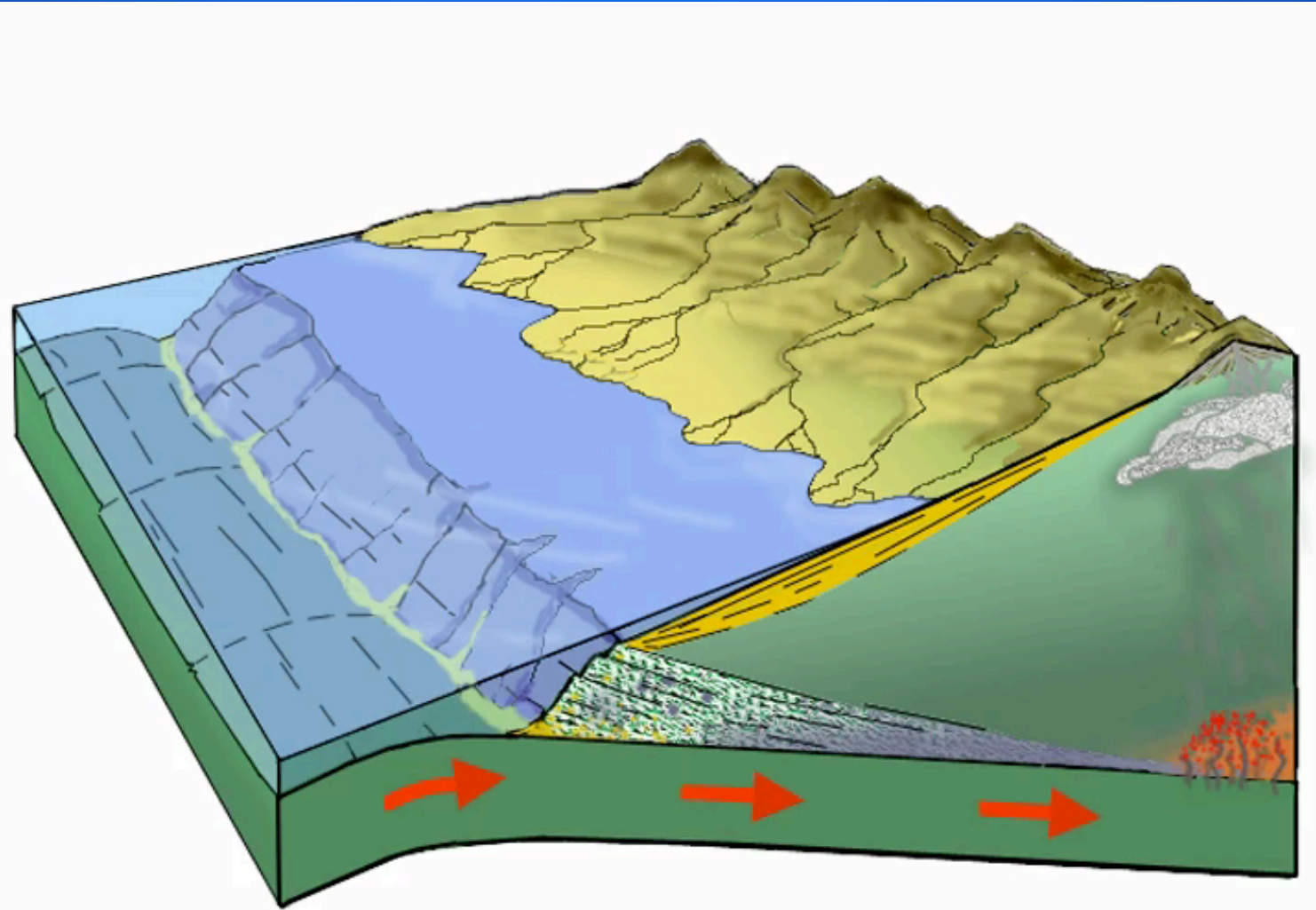
*Oceanic crust toward oceanic crust - e.g., northern Pacific*

*Continental crust toward continental crust – e.g., Himalayas*



*Compression at convergent boundaries produces buckling and shortening*

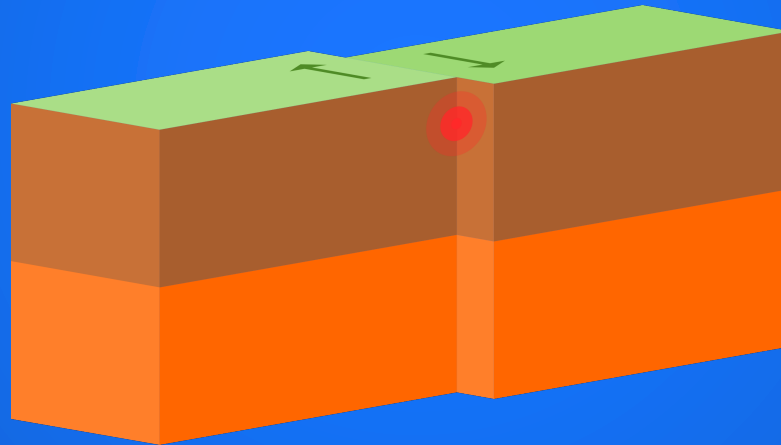
# Convergent Plate Boundaries



# Transform Plate Boundaries

locations where crustal plates move past one another

Nearby example: San Andreas Fault



Interaction at transform boundaries causes shear



# Confirming Plate Tectonics

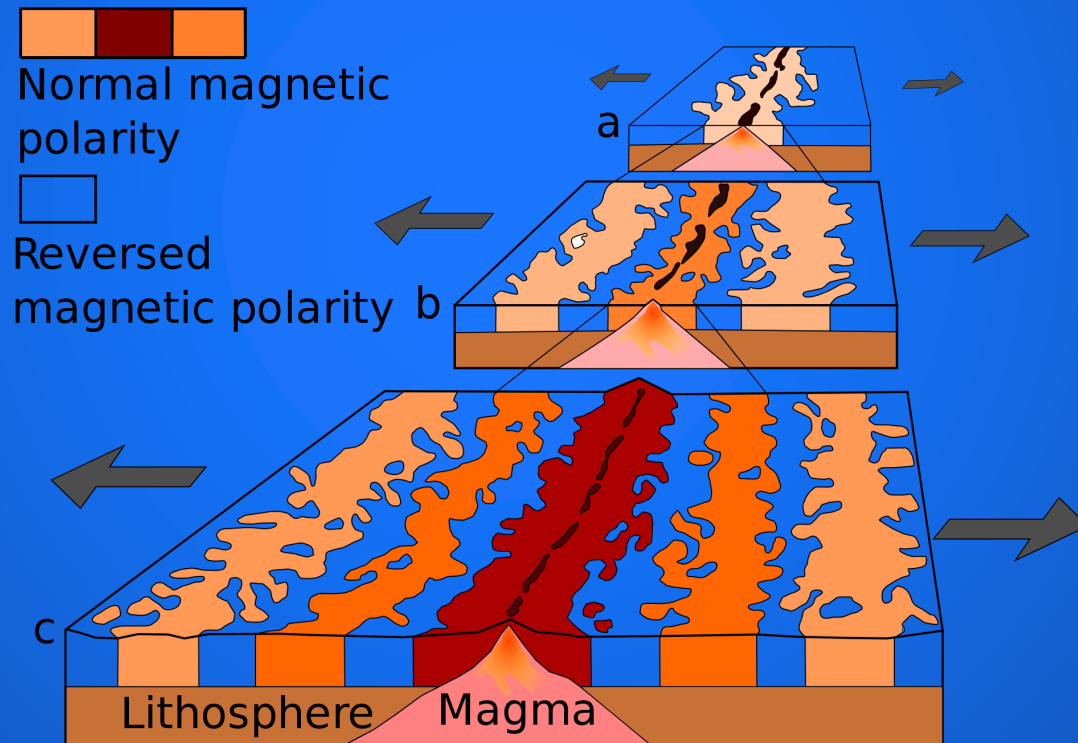
**Age and distribution of ocean sediments**

**The Oceanic ridges**

**Earthquakes at depth  
(~700km; suggests rigid lithosphere subducting)**

# Confirming Plate Tectonics

**Paleomagnetism:** strips of alternating magnetic polarity at spreading regions.



# The age and magnetic reversals of volcanic seafloor

Age of Atlantic Ocean Basin  
millions of years

0-5
5-21
21-38
38-52
52-65
65-144
144-160



# Confirming Plate Tectonics

**Hot Spots:** Surface formations from plumes of magma

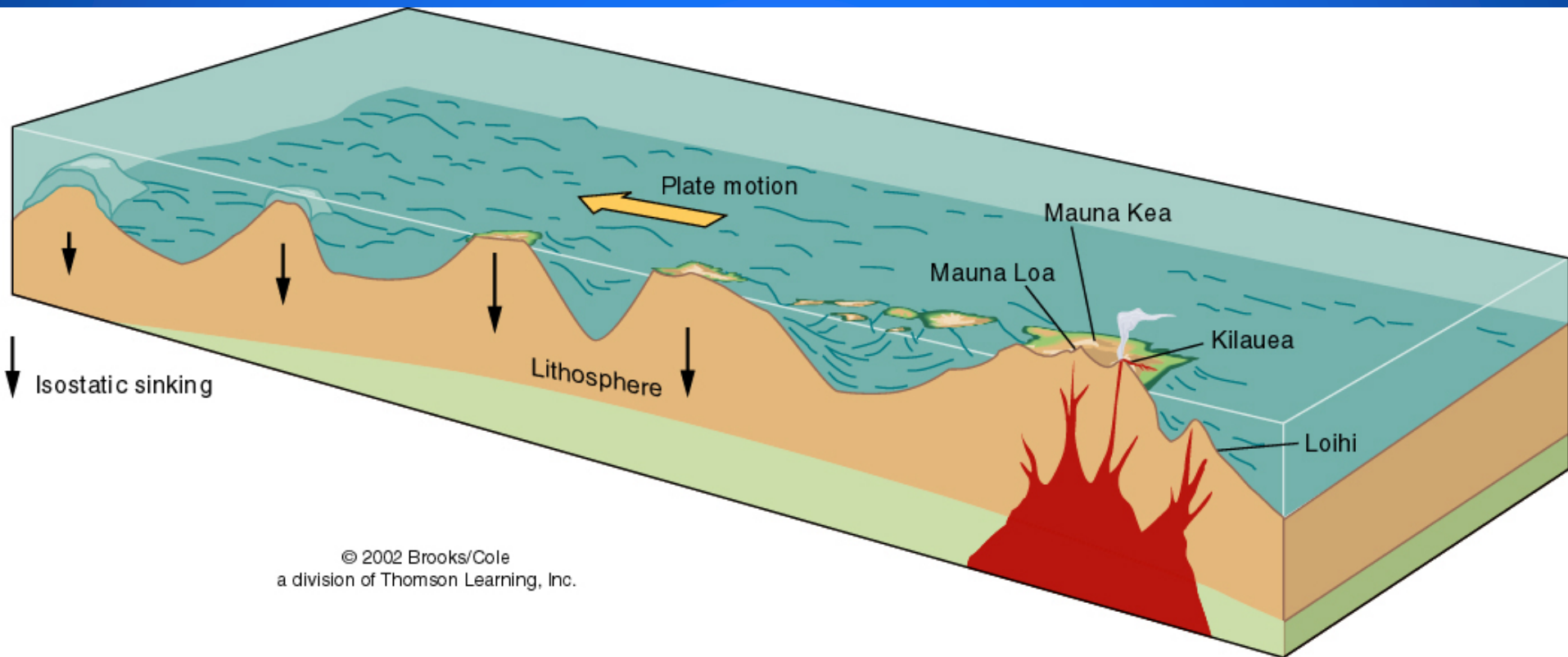


plate moving over *stationary* lava plume... result: volcanic chain



## The Hawaiian islands...

- A) Formed near a subduction zone as a volcanic arc
- B) Formed at a divergent boundary
- C) Didn't form at a plate boundary
- D) Were once located at the south pole



# Confirming the Theory of Plate Tectonics

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