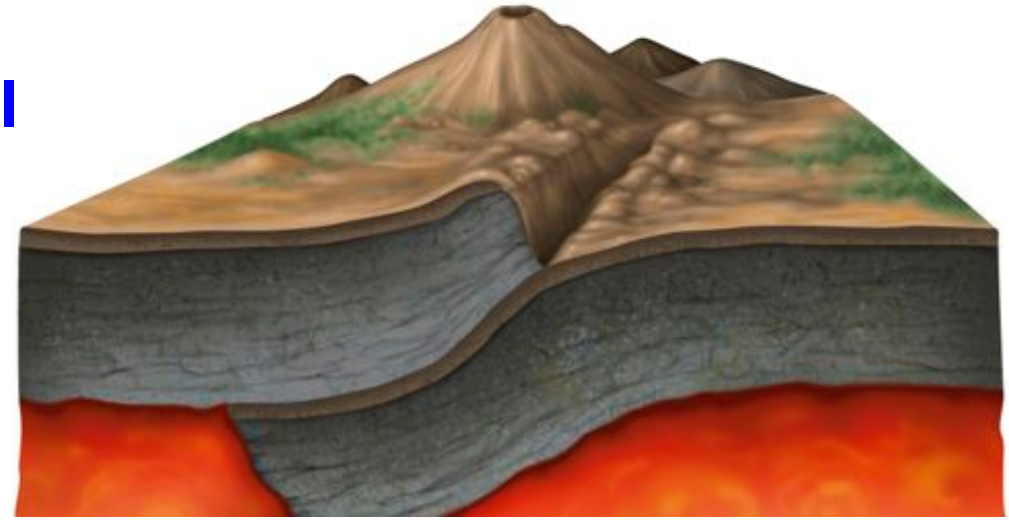
Lecture 10: Plate Tectonics I

1. Midterm 1 scores returned
2. Homework #9 due Thursday 12pm

Learning Objectives (LO)

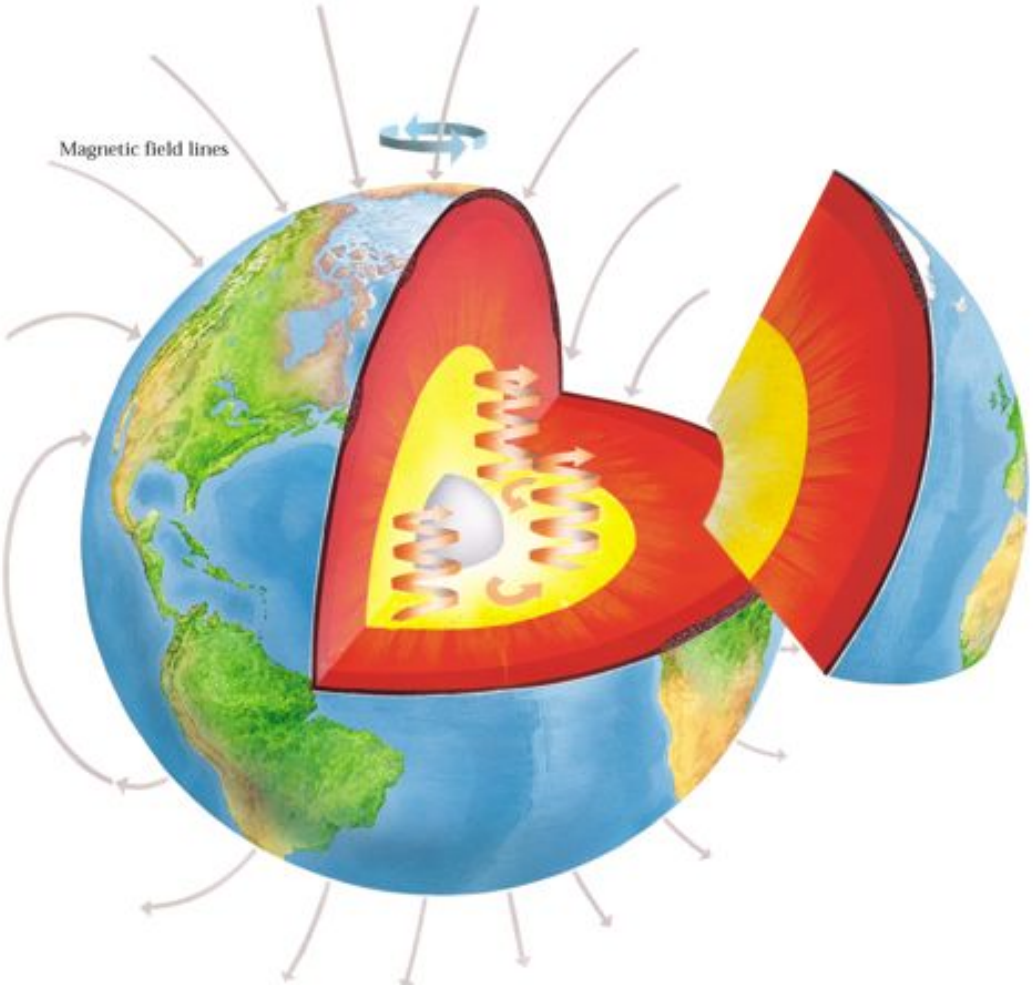
Lecture 10: Plate Tectonics I
** Chapter 3 **

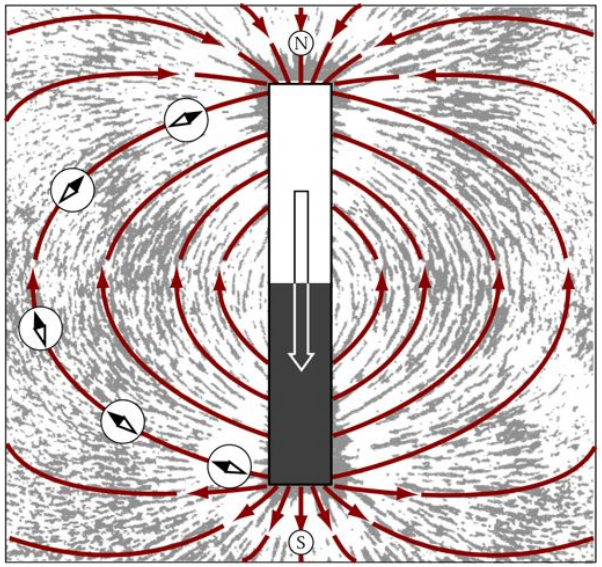


What we'll learn today:

1. Describe the origin and recycling of oceanic crust
2. Identify the evidence that the polarity of Earth's geomagentic field has reversed in the past
3. Describe the additional evidence that supports the theory of plate tectonics

Earth's Magnetic Field





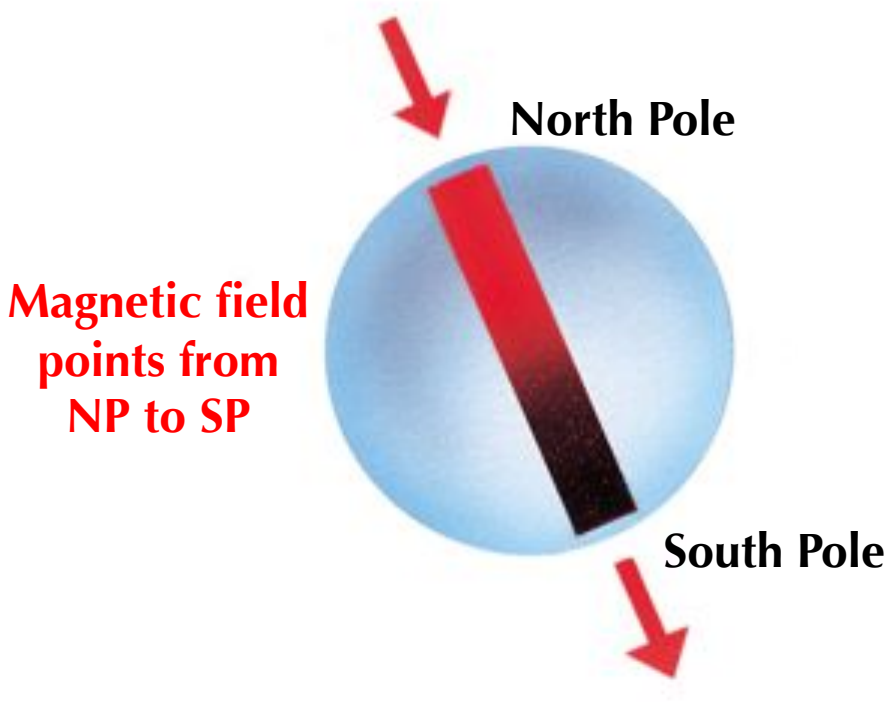
- Earth's magnetic field is like a bar magnet

- Has a **north** and **south** pole; reverses direction every ~ few million yrs

Reversals of the Magnetic Field

- Earth's magnetic field can be represented by a **dipole** that points from the north magnetic pole to the south

- Every now and then, the magnetic polarity **reverses**

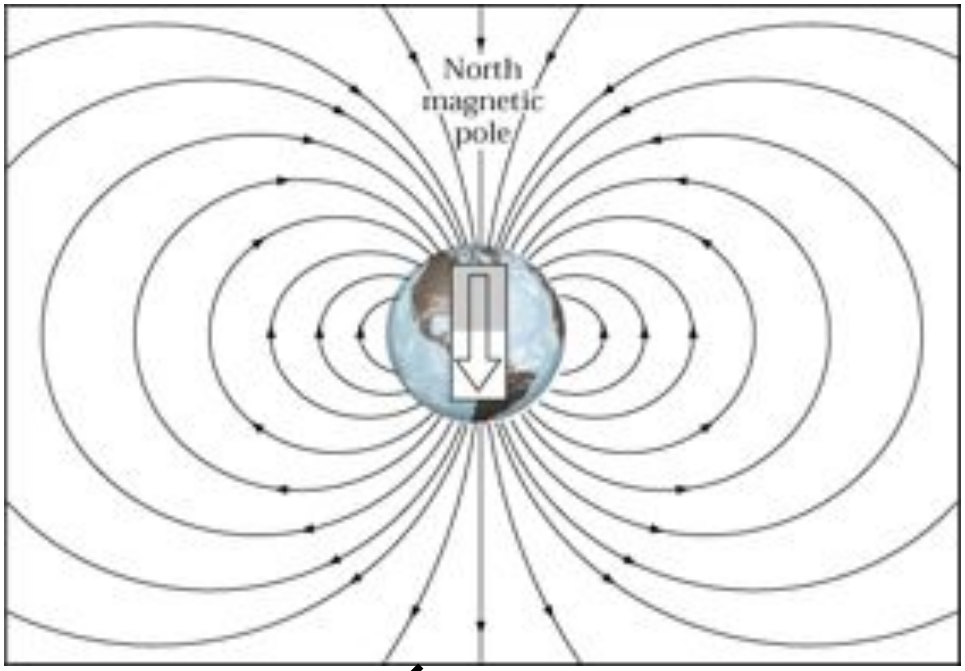


Normal polarity (today)

Magnetism and Rocks

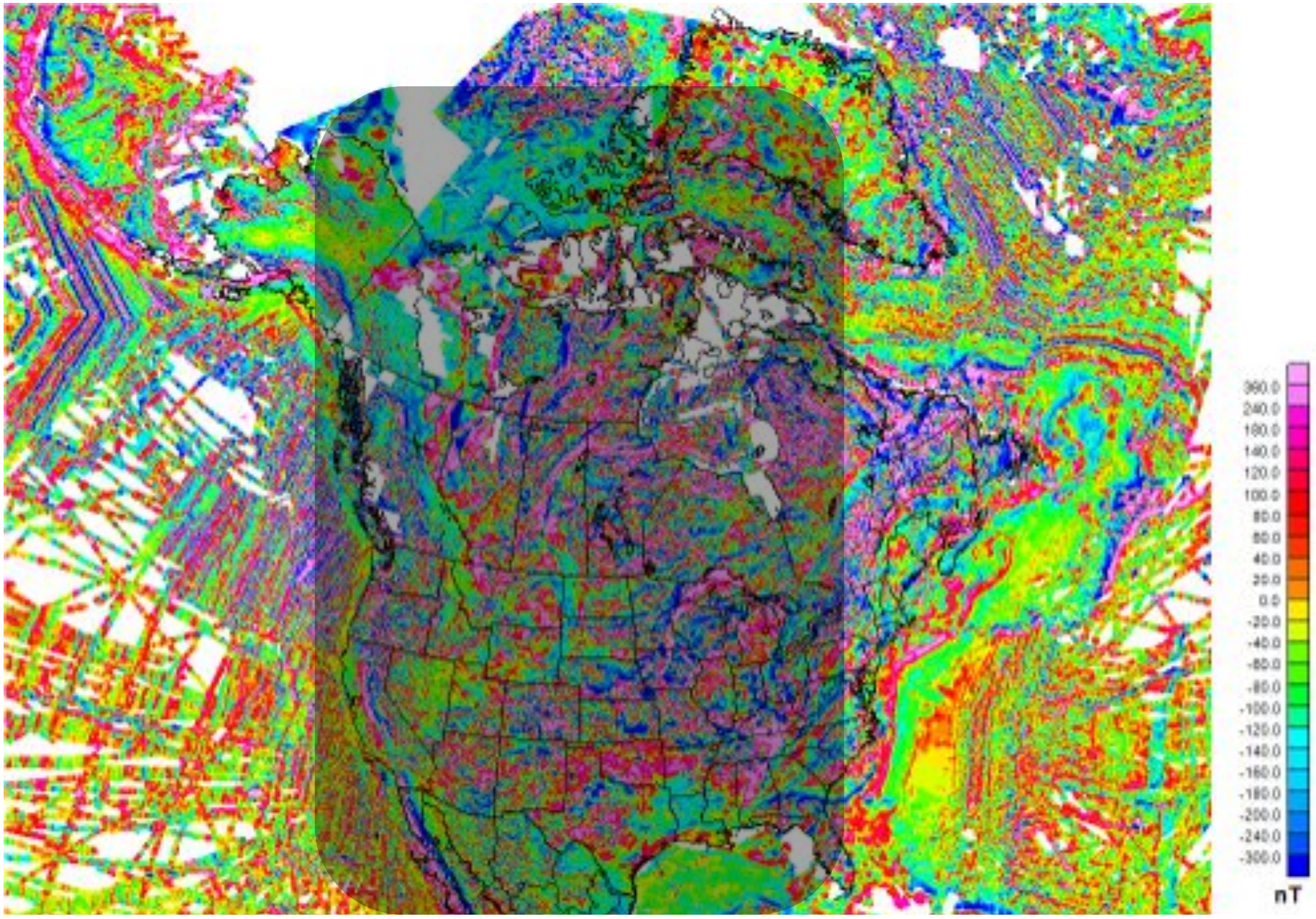
Rocks get magnetized when lava flows

Basalt contains magnetite, a strongly magnetic mineral



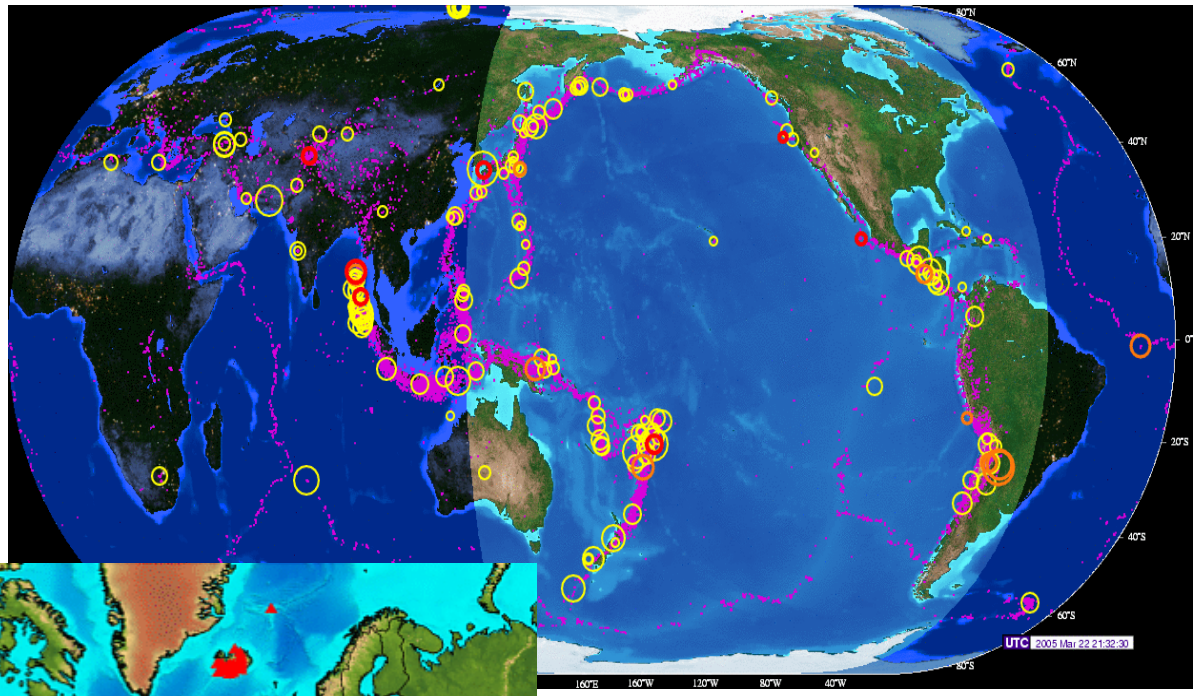
Lava records magnetic field of Earth

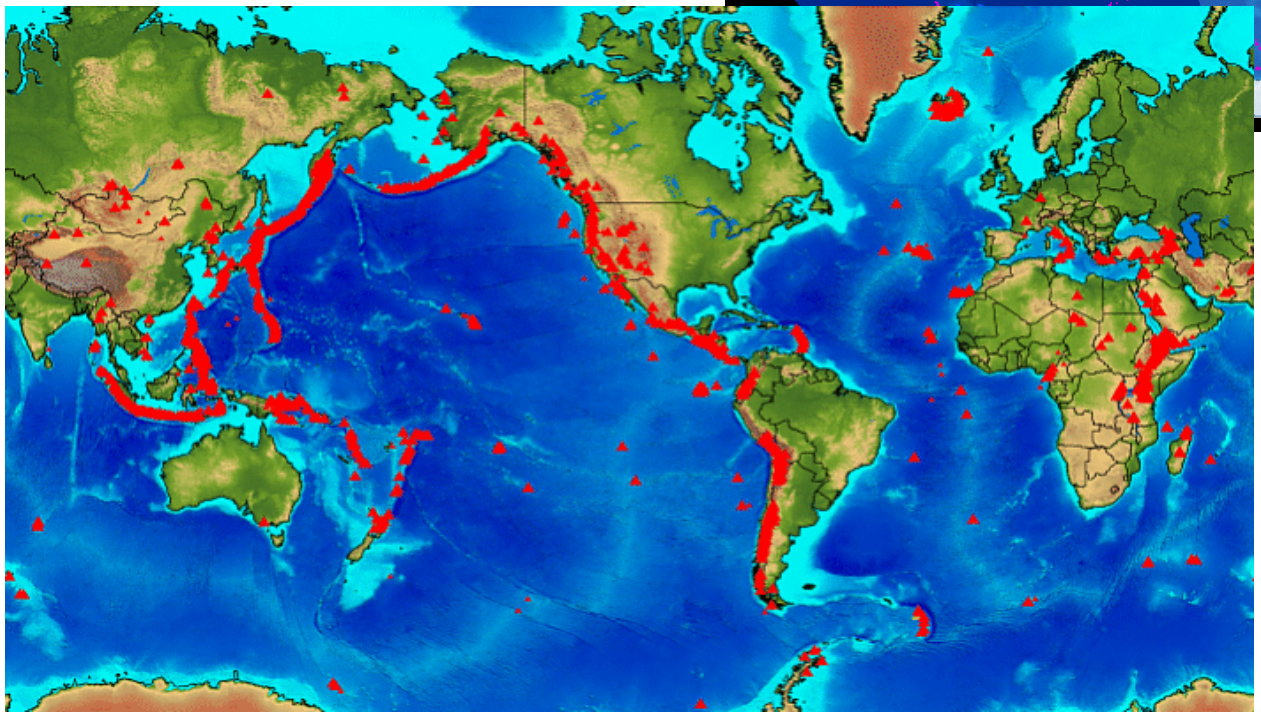
Magnetism and the Sea Floor: *Stripes?*



The Plate Puzzle

Volcanoes & EQs occur along similar boundaries.





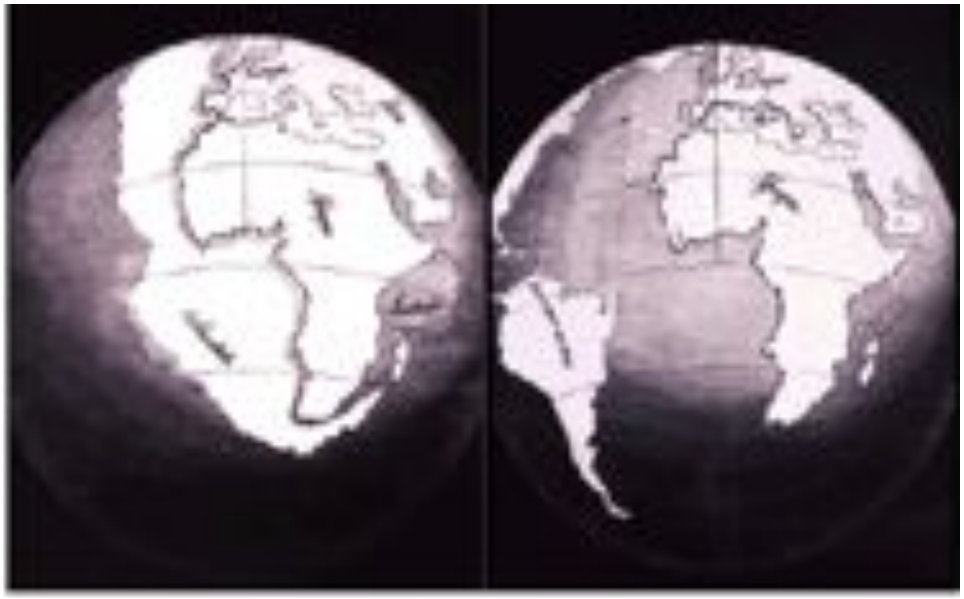
WHY?

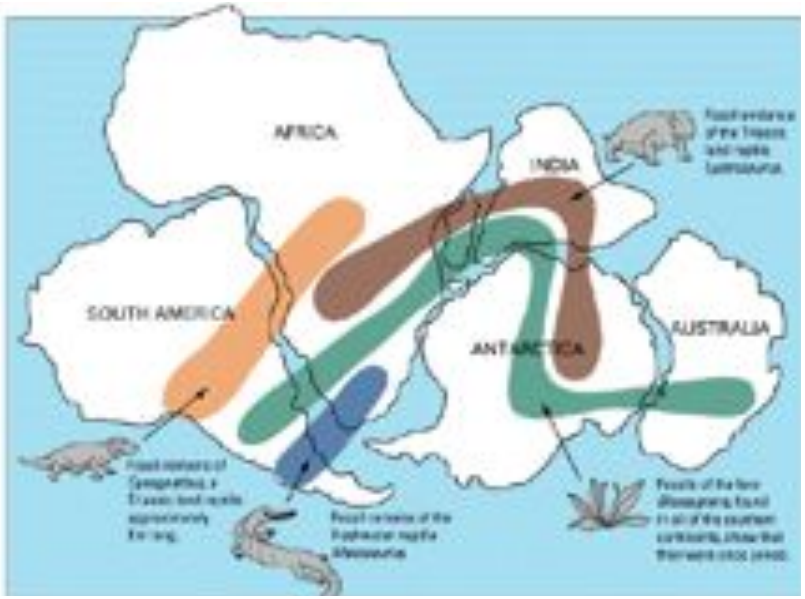
Continental Drift

Alfred Wegener (1880-1930)

- **Observations:** jigsaw puzzle fit of South America & Africa
  coastal fossil records of S. America and Africa

- **Theory:** supercontinent Pangea split up 200 million years ago

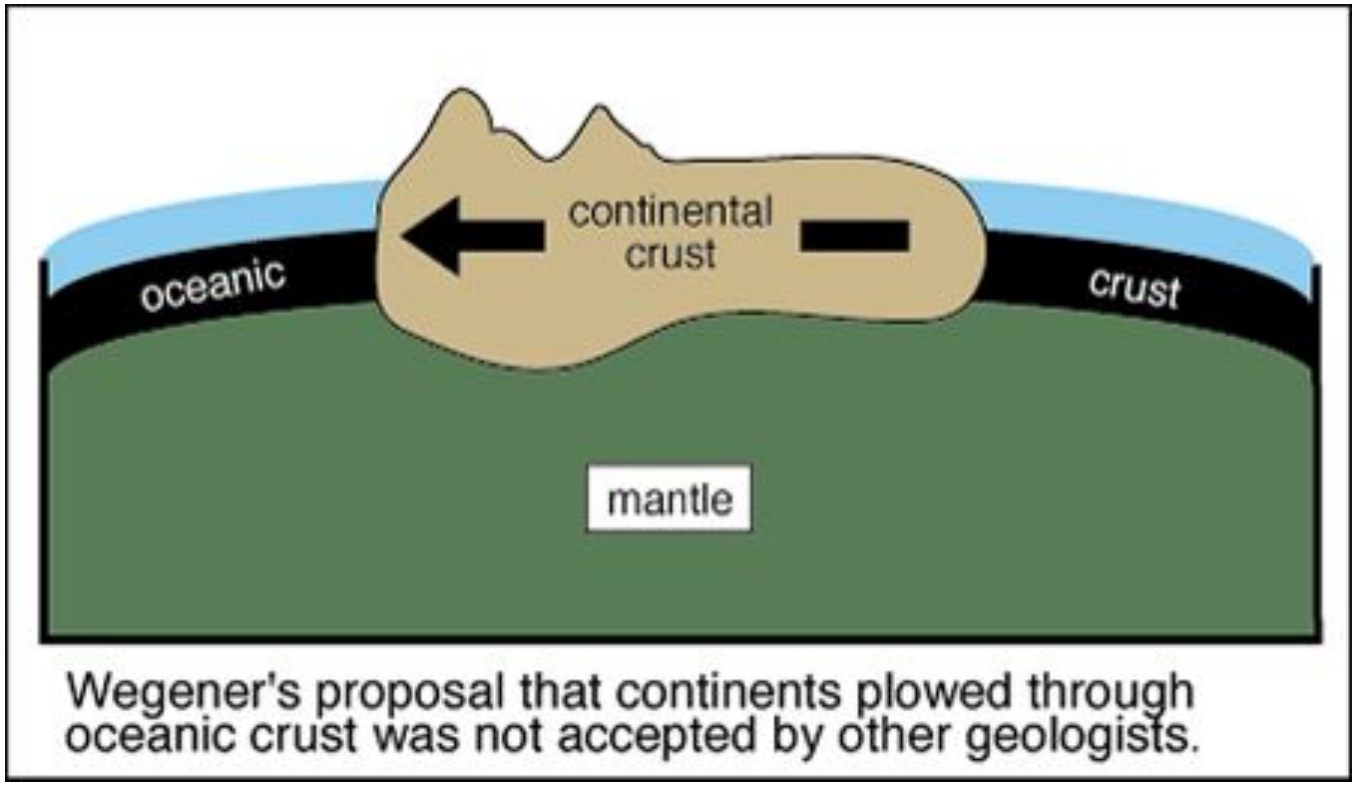




Wegener's Idea (1915)
The Origin of Continents and Oceans

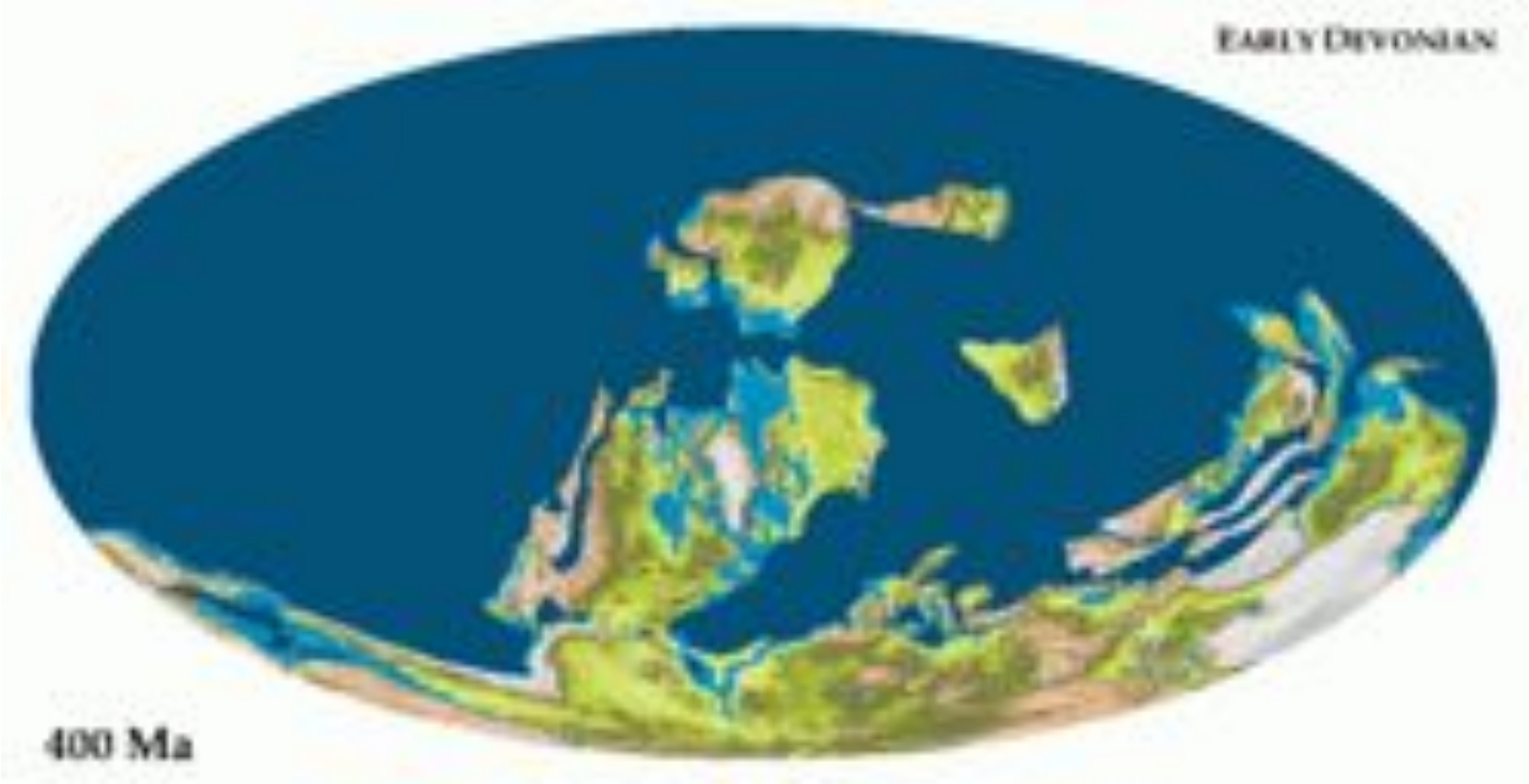
Continental Drift: the continents plowed through the oceanic crust

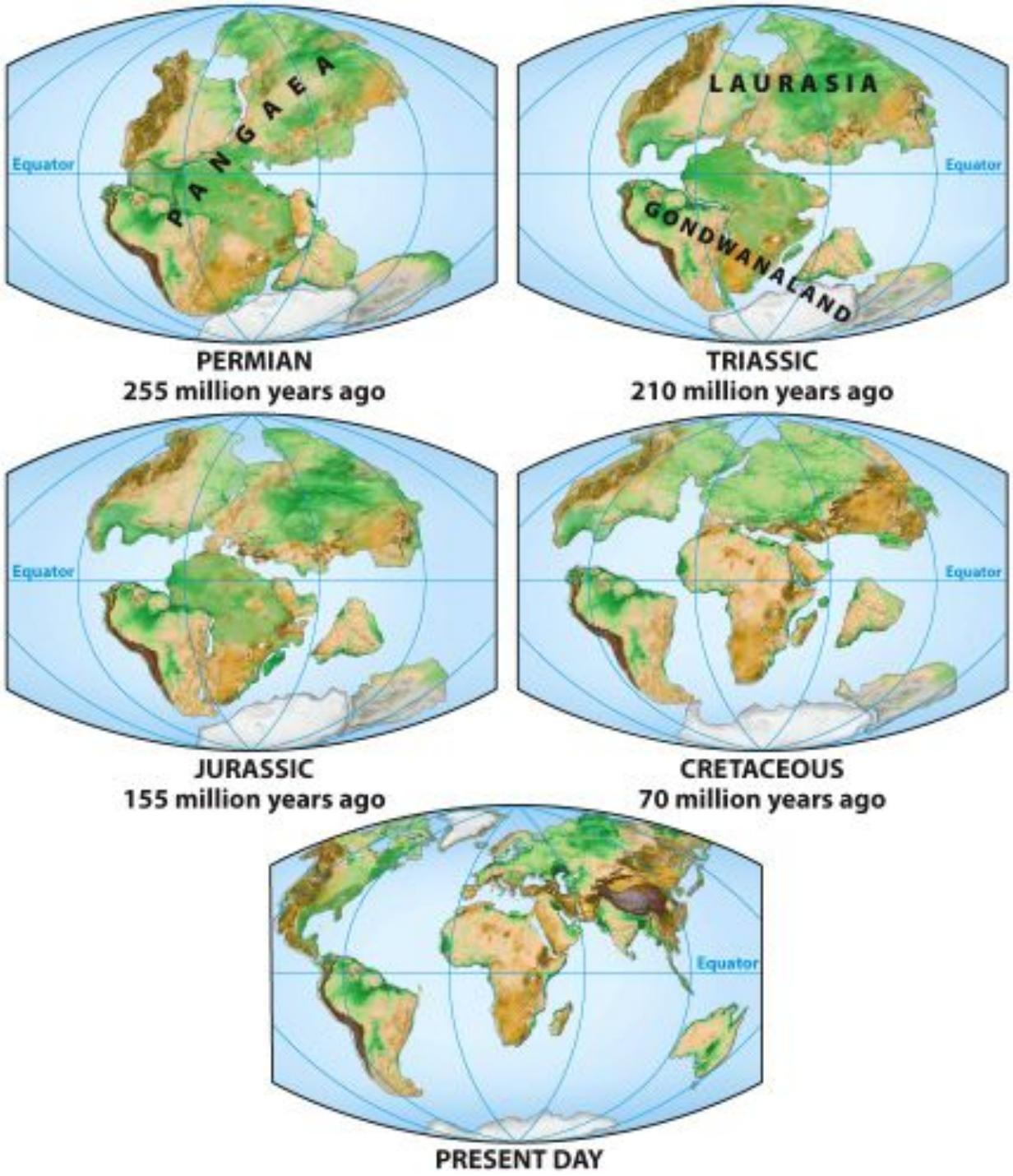
Problem: Wegener did not describe the forces that caused continents to move!



Wegener's proposal that continents plowed through oceanic crust was not accepted by other geologists.

Continental Drift



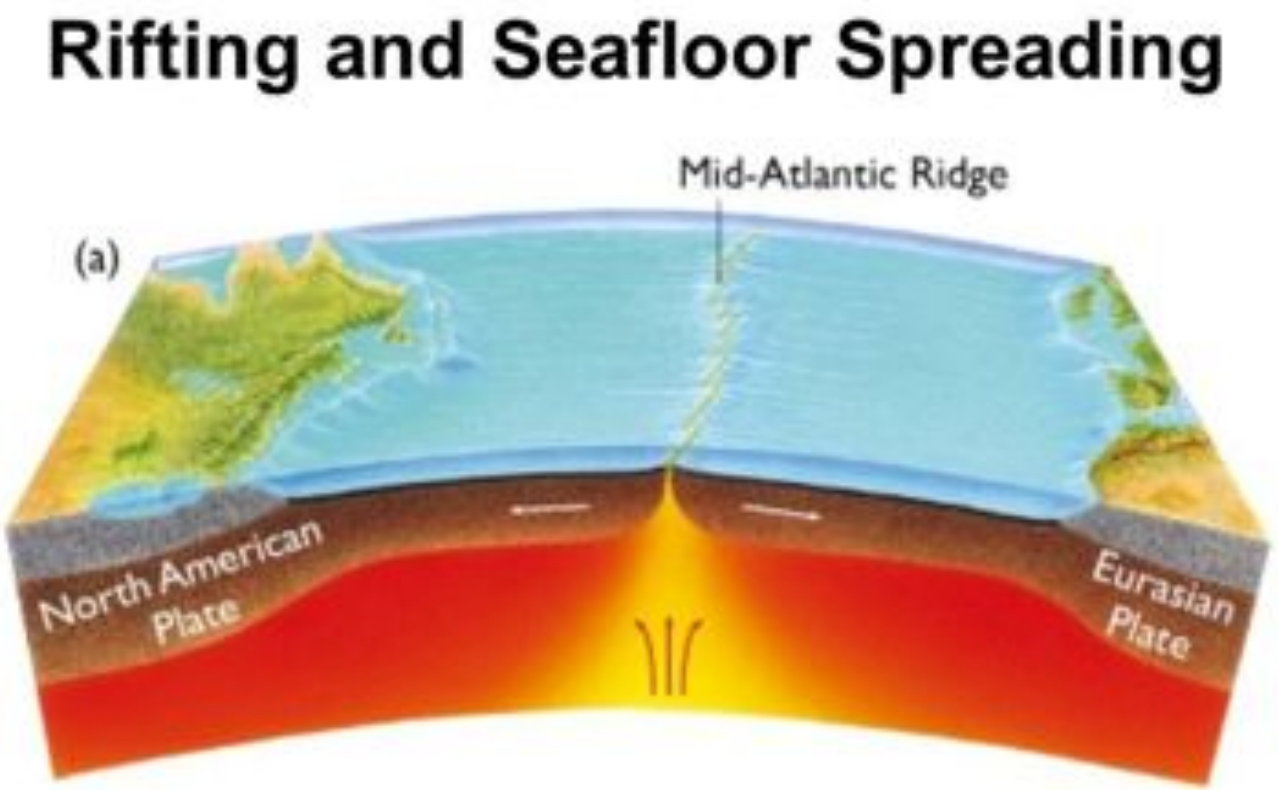


MODERN CONTINENTS EVOLVED FROM

PANGEA

1960s: The Development of Plate Tectonics

Harry Hess, 1962: “A History of the Ocean Basins”
Seafloor spreading allows plates to move

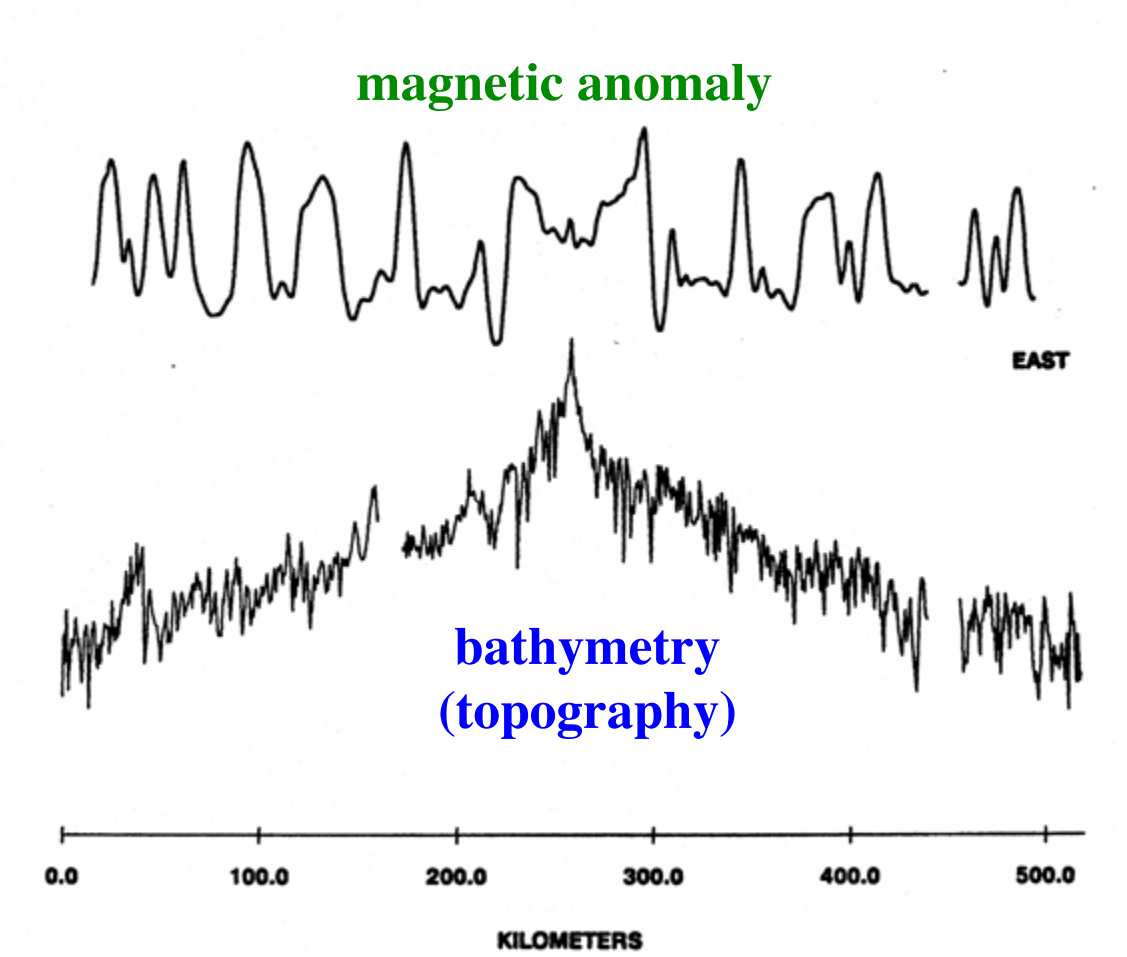


Explains volcanism (rifting) in the center of oceans.

Prediction:
The seafloor is youngest near the spreading center.

1950s - Magnetic Field Surveys of the Seafloor

Across the Atlantic Basin

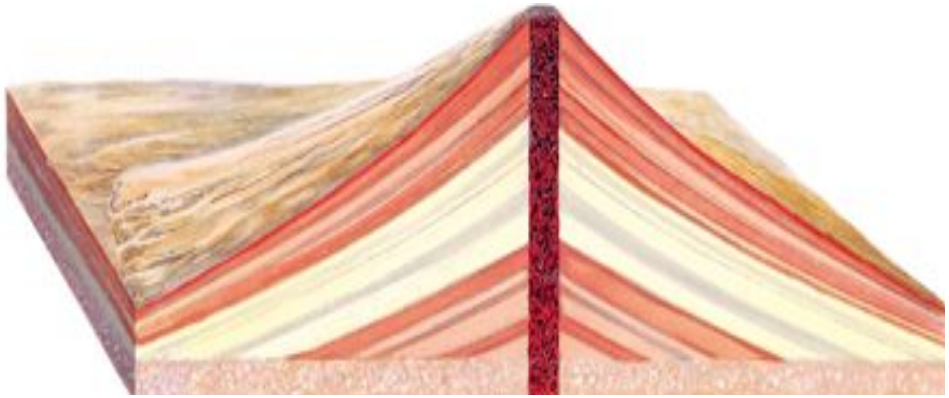


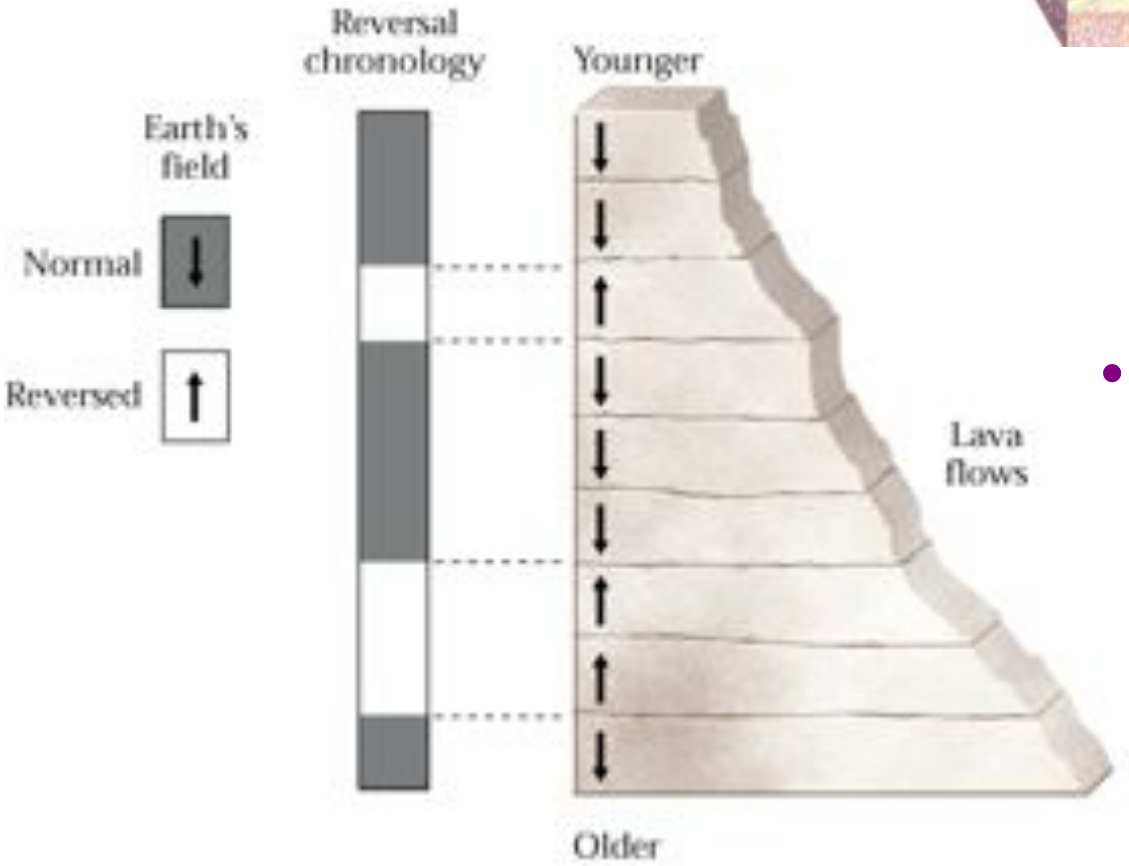
Magnetic Anomaly:
symmetric about ridge

Seafloor Bathymetry:
A high “ridge” in the middle of the Atlantic

Recording Magnetic Reversals in Rocks

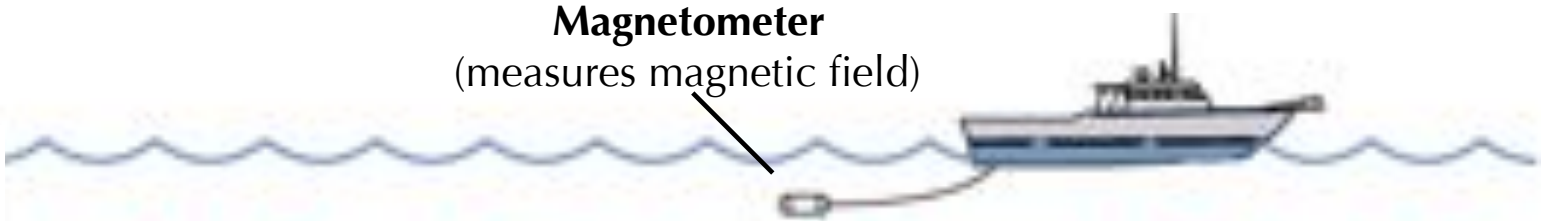
- Layers of volcanoes record magnetic field changes over time

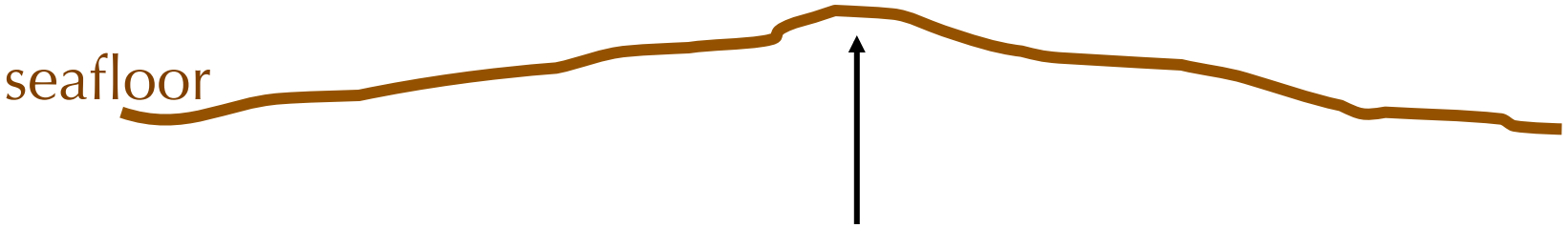




- Layers reveal flip-flops of normal polarity and reversed polarity

Mag. Reversals Recorded in Seafloor Rocks

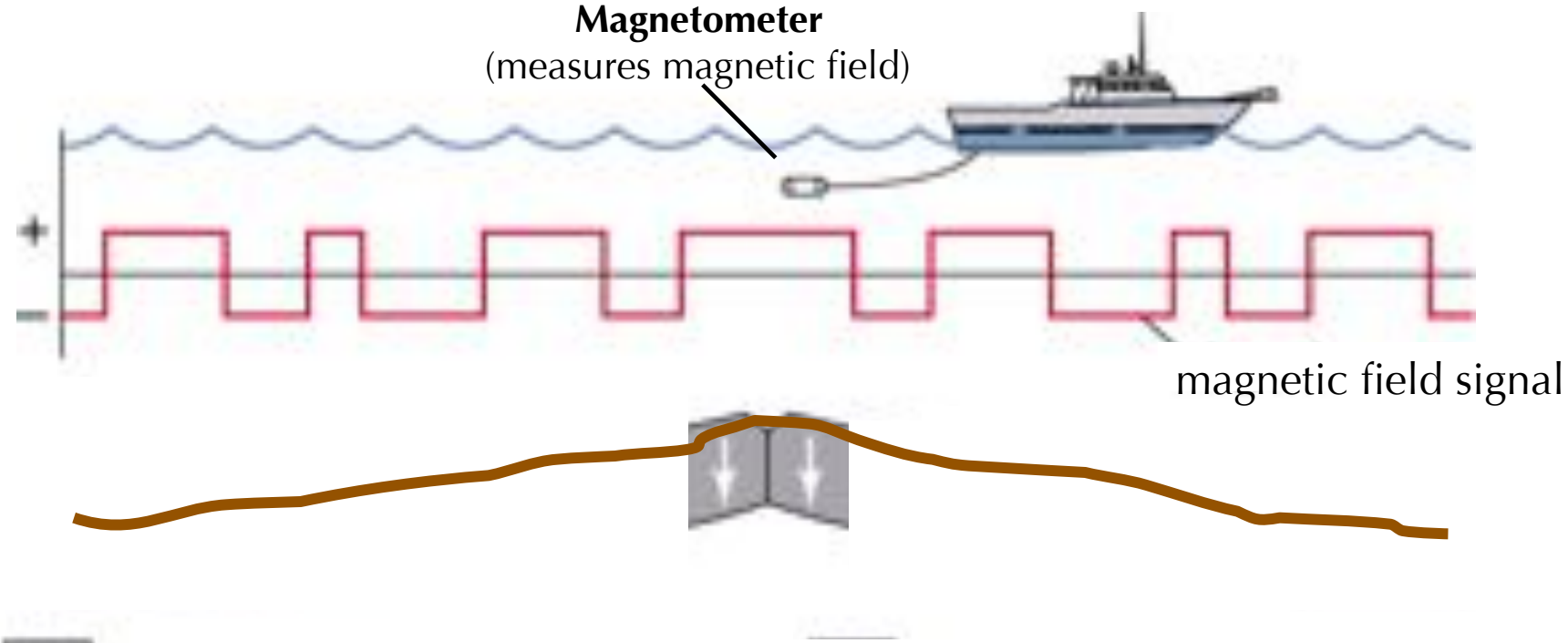




Ocean Ridge

\+ same polarity as today (normal)
\- different polarity (reversed)

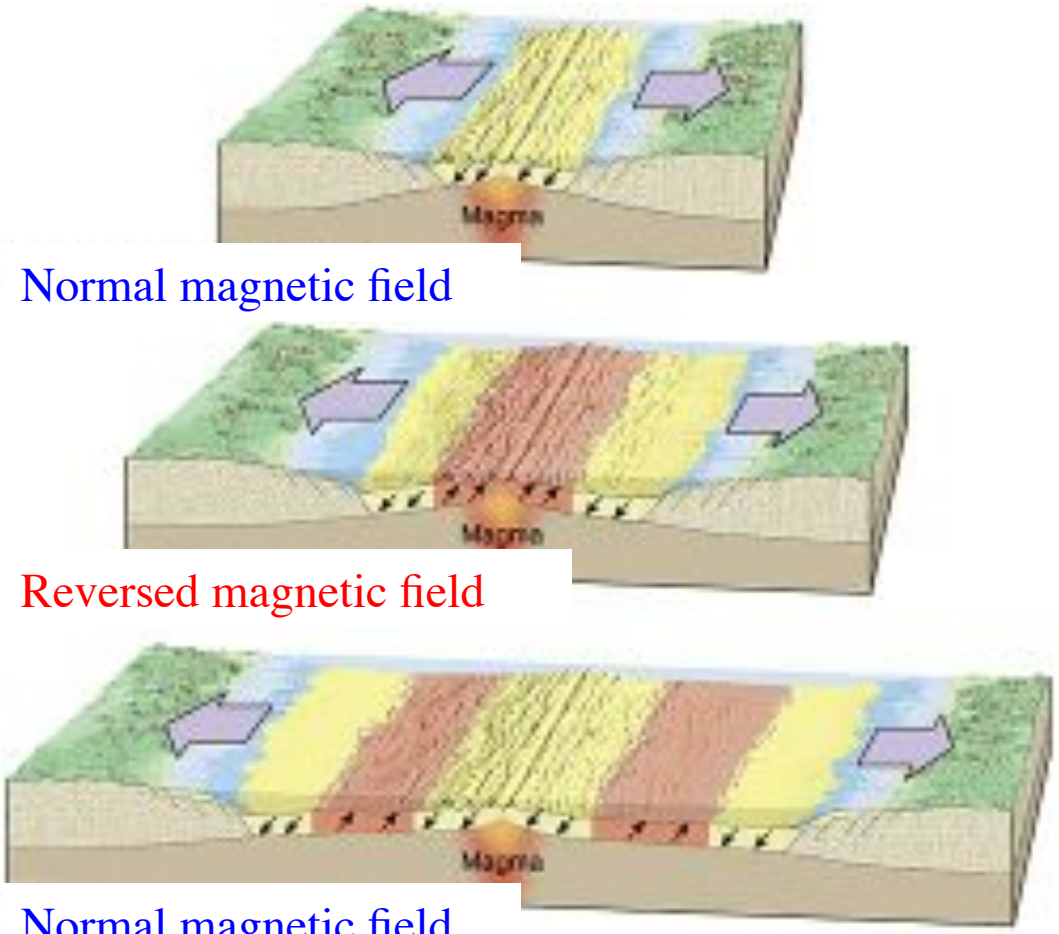
Mag. Reversals Recorded in Seafloor Rocks



Normal magnetic field polarity

Seafloor Magnetic Reversals

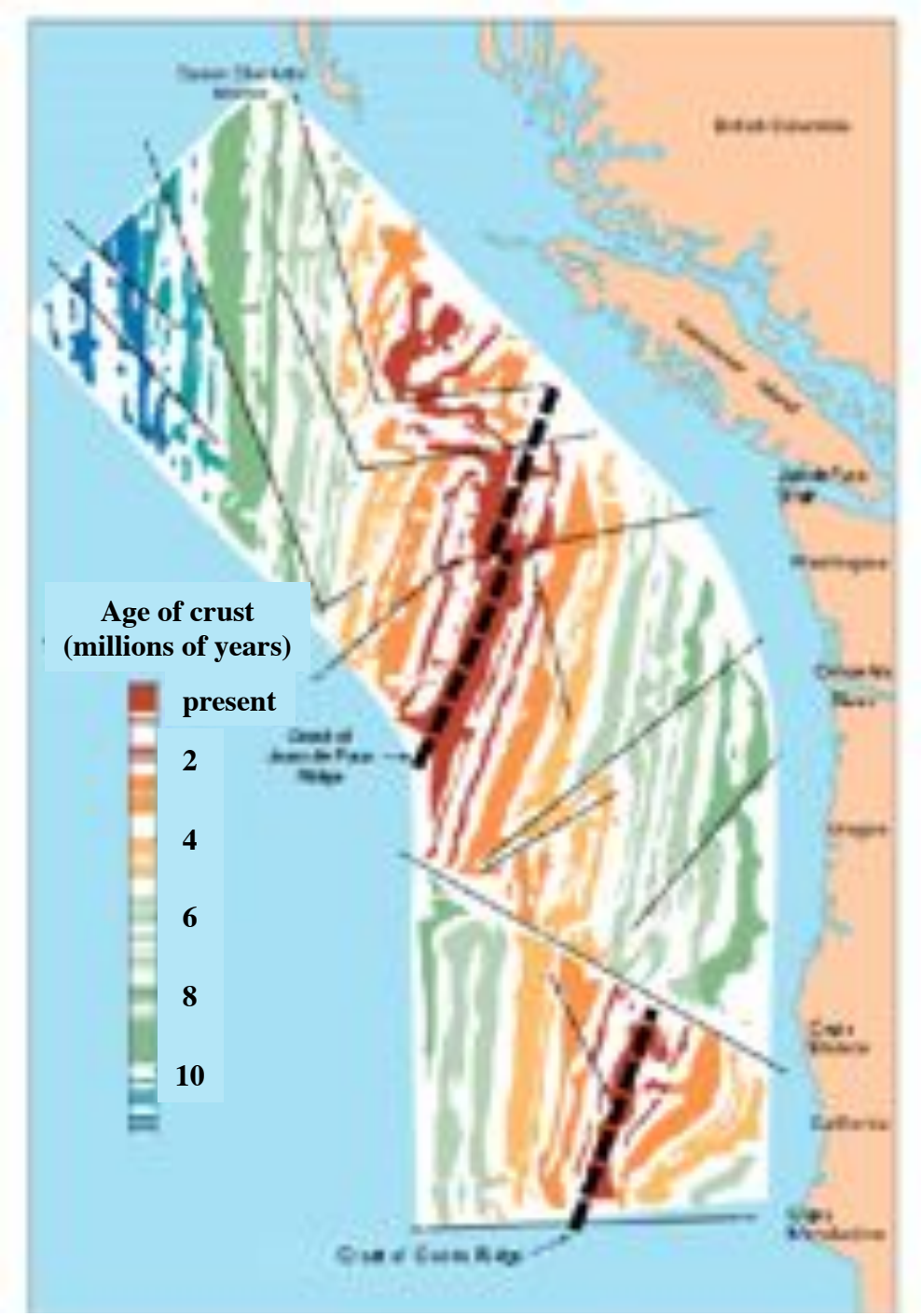
• Oceanic crust preserves a record of Earth's magnetic polarity at the time the crust formed



New seafloor is being created as the seafloor spreads.

The continents move apart as new seafloor expands the ocean basin

The magnetic field is "frozen" in the newly-created seafloor.



"Stripes" & Seafloor Age

- The pattern of magnetic "stripes" discovered all over ocean floor

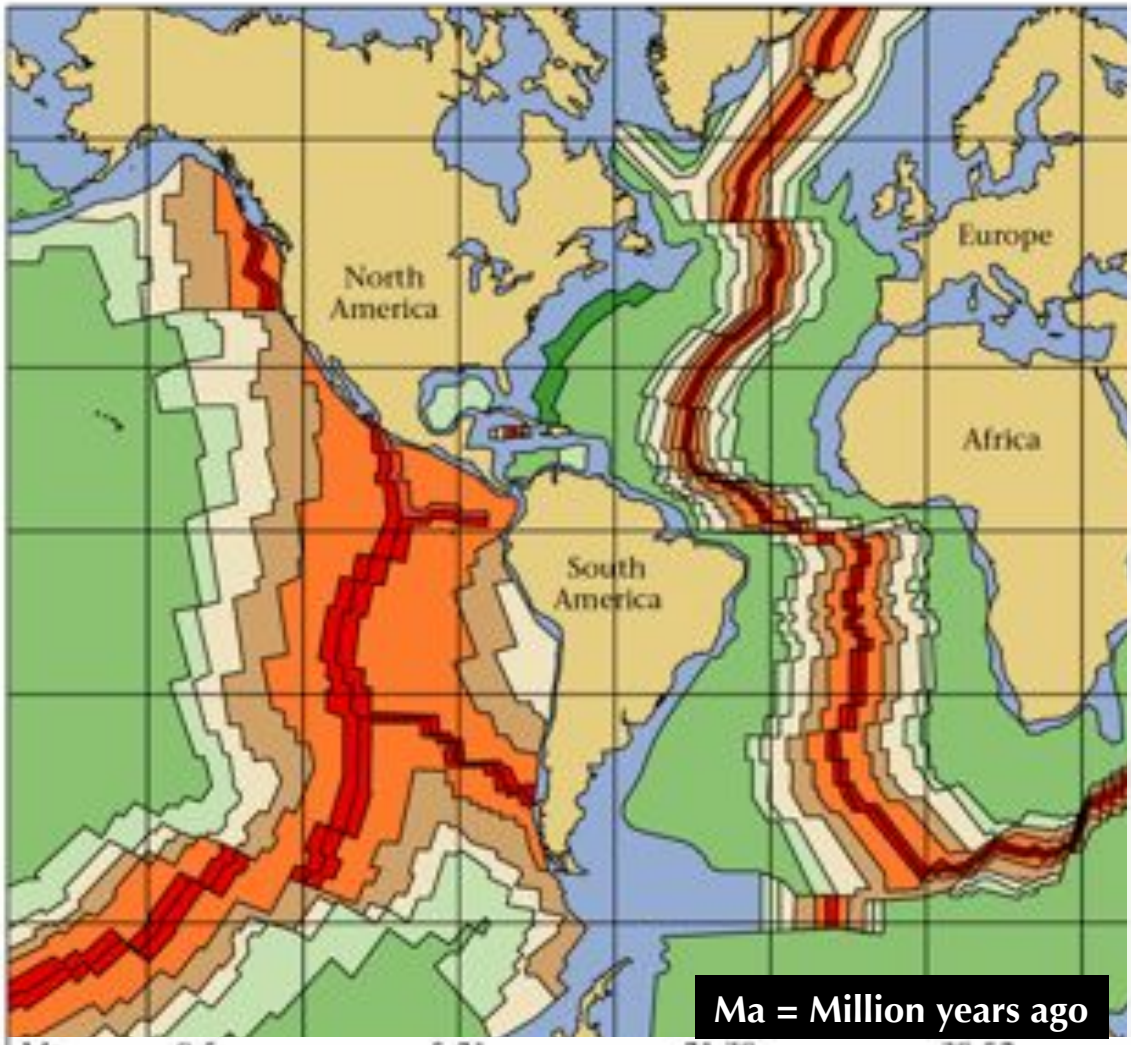
- **Found:** increasing seafloor age away from ridge center

  - young rocks ⟶ nearby
  - old rocks ⟶ far away

Seafloor Spreading

Frederick Vine: https://www.youtube.com/watch?v=ecGzjo73vUc

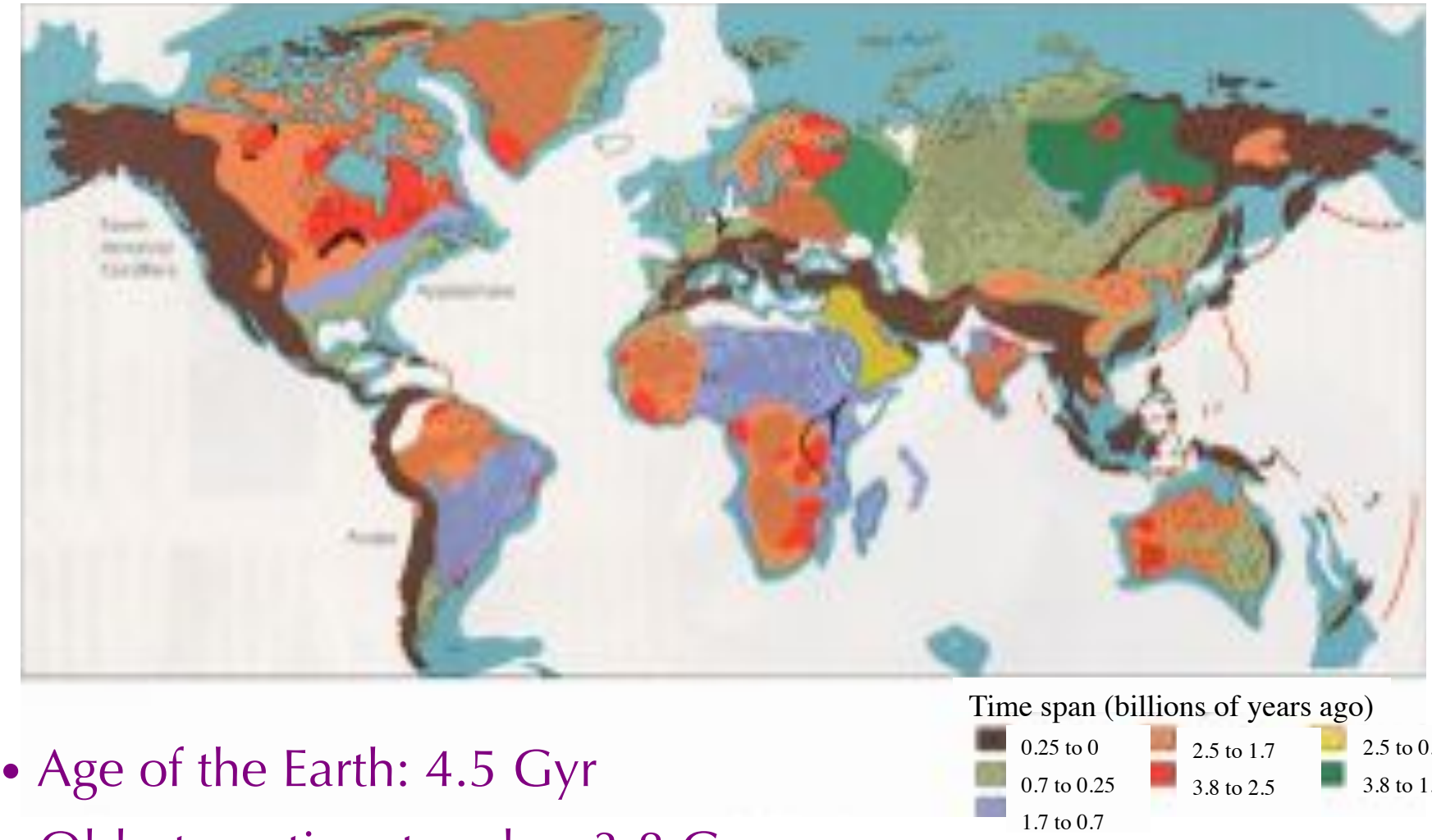
Ages of the Ocean Floor



- Seafloor ages vary from 0 to ~160 Ma with a distinctive pattern
- Oldest seafloor is **much** younger than most of continental crust

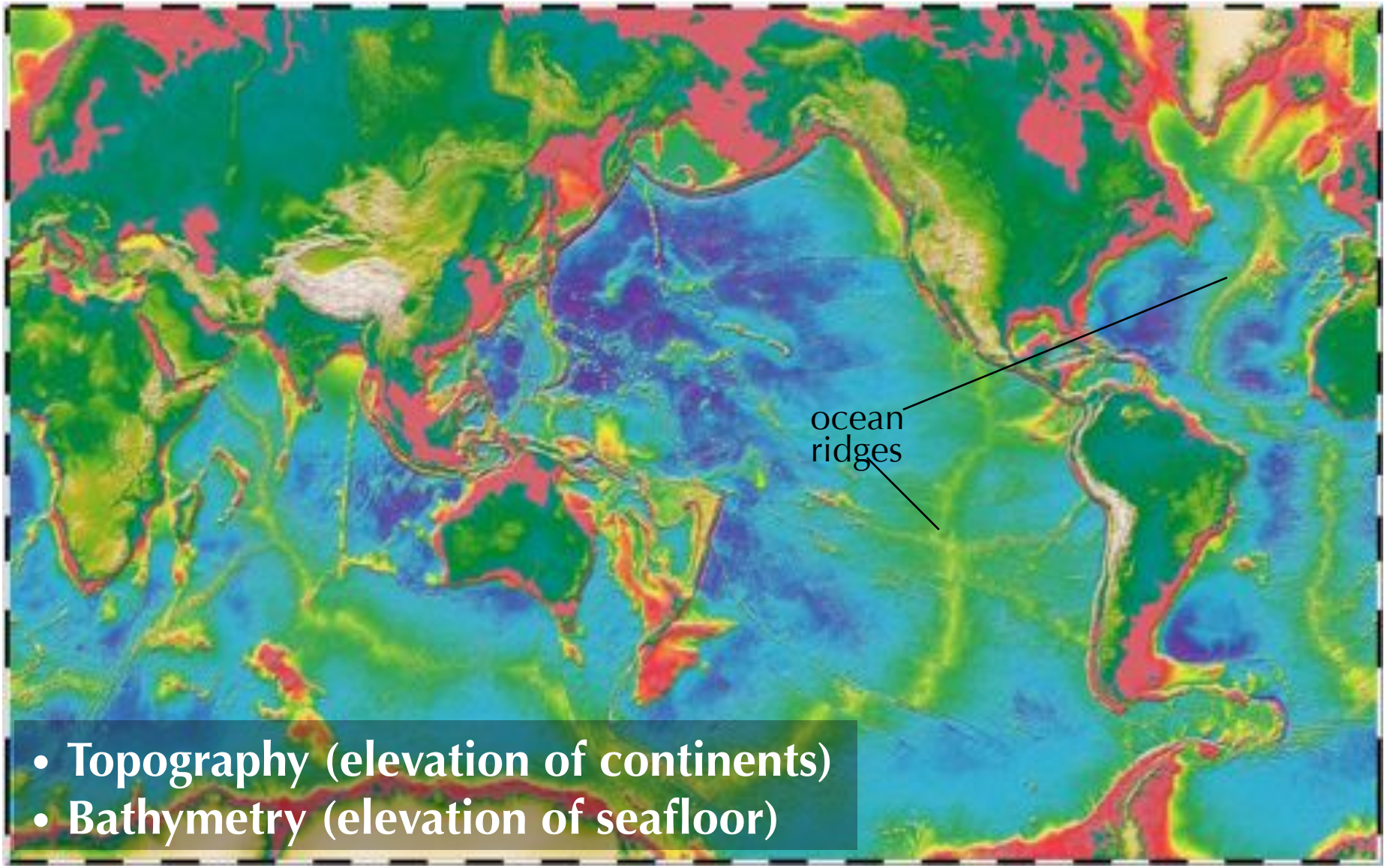
1 billion years = 1 Gyr
1 million years = 1 Myr
1 thousand years = 1 kyr

Ages of Continental Rocks



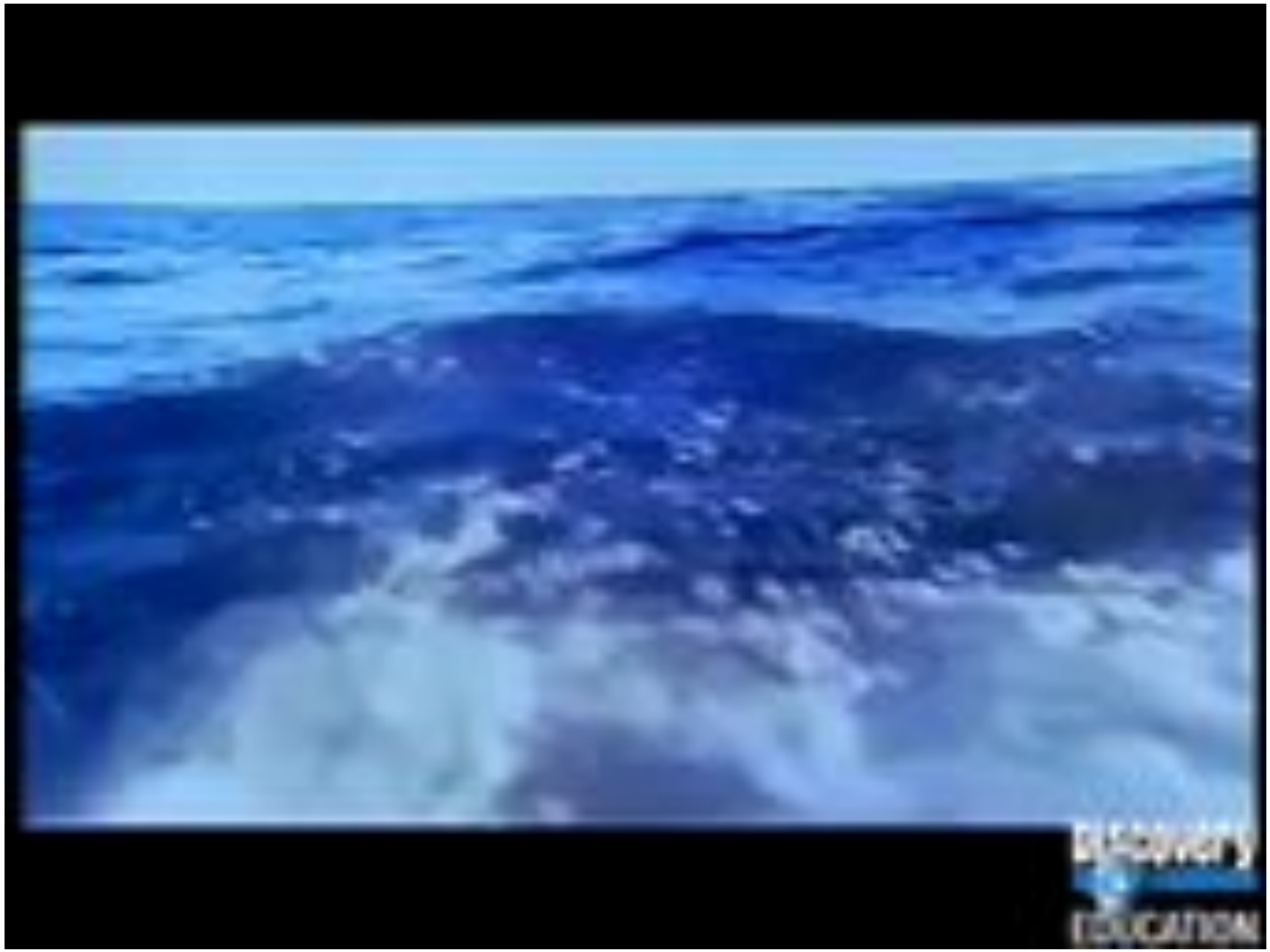
- Age of the Earth: 4.5 Gyr
- Oldest continent rocks: 3.8 Gyr
- Youngest continent rocks: 250 Myr

Global Topography and Bathymetry



- Topography (elevation of continents)
- Bathymetry (elevation of seafloor)

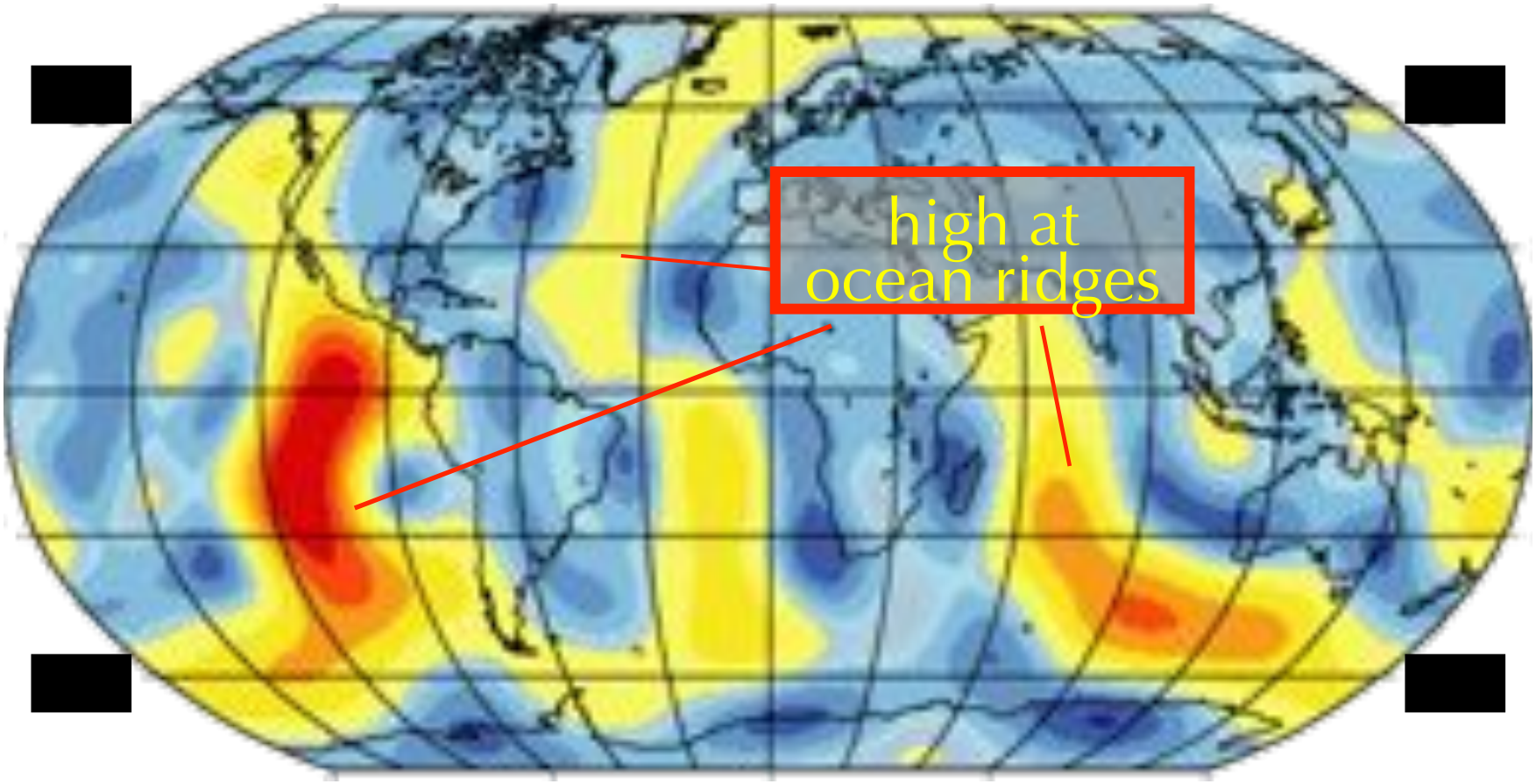
Mystery Mountains on the Seafloor



https://www.youtube.com/watch?v=GyMLlLxbfa4

Fig.4.11a

Heat Flow



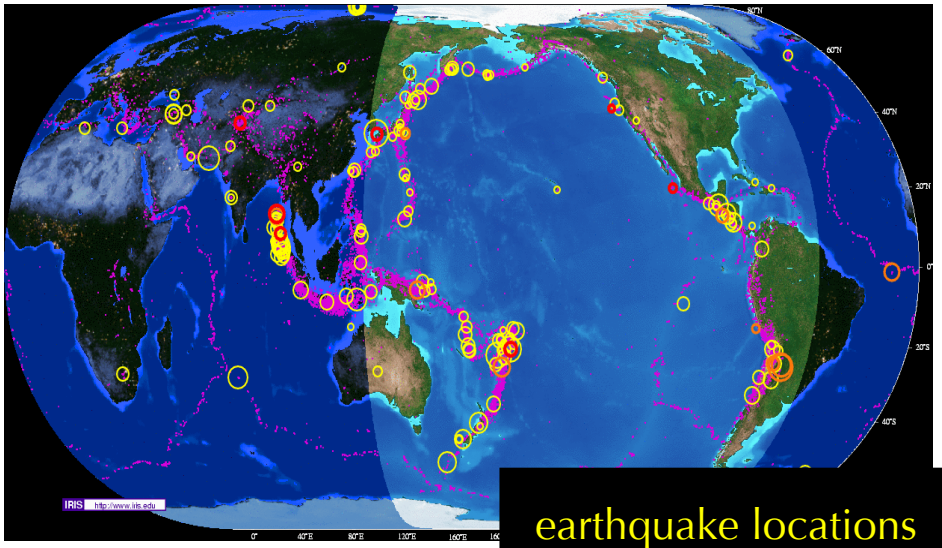
Warm colors = higher heat flow
Cool colors = lower heat flow

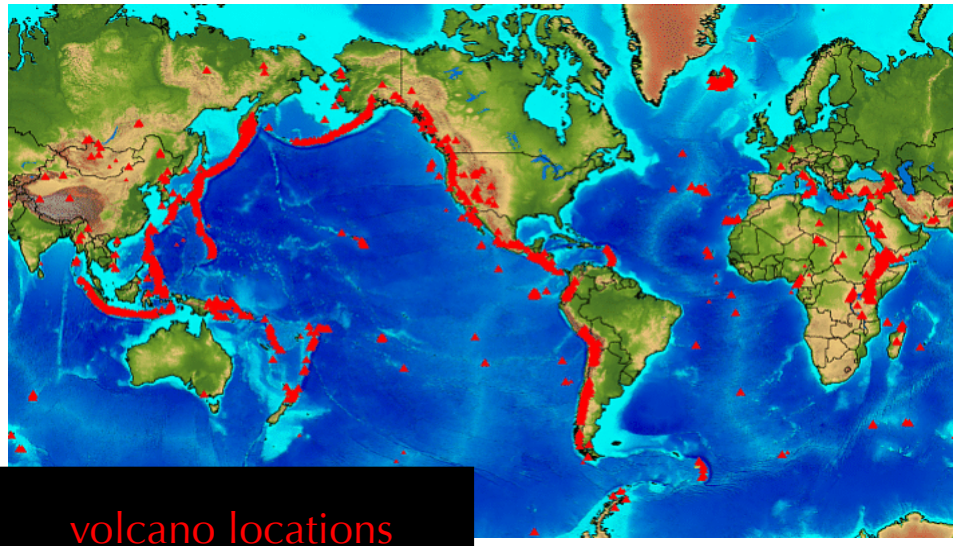
Fig.4.11a

Heat Flow & Bathymetry

- Heat flow is **high** at a ridges and lower further away
- Crust bathymetry is **high** at ridges because it is hot and buoyant
- Away from a ridge, the crust has cooled and sunk --> seafloor is lower

The Puzzle Solved…..





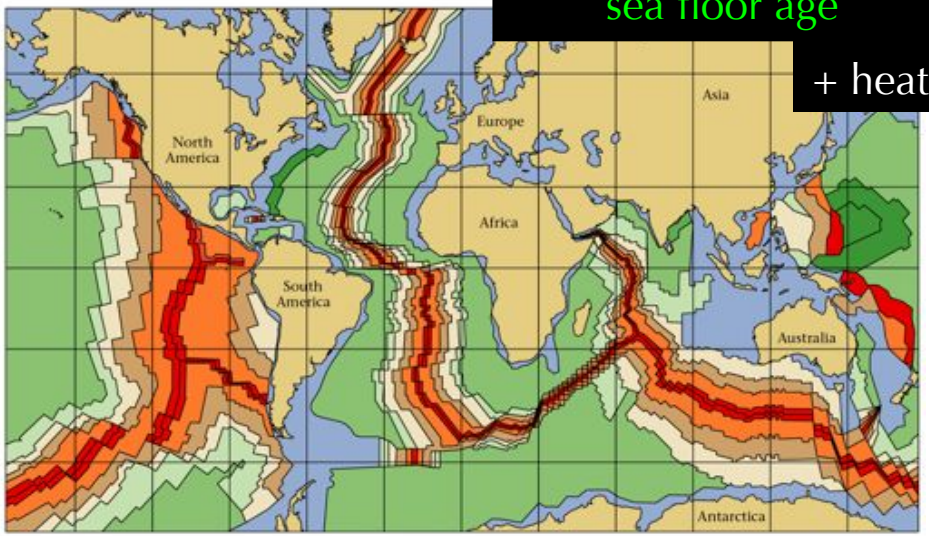
earthquake locations

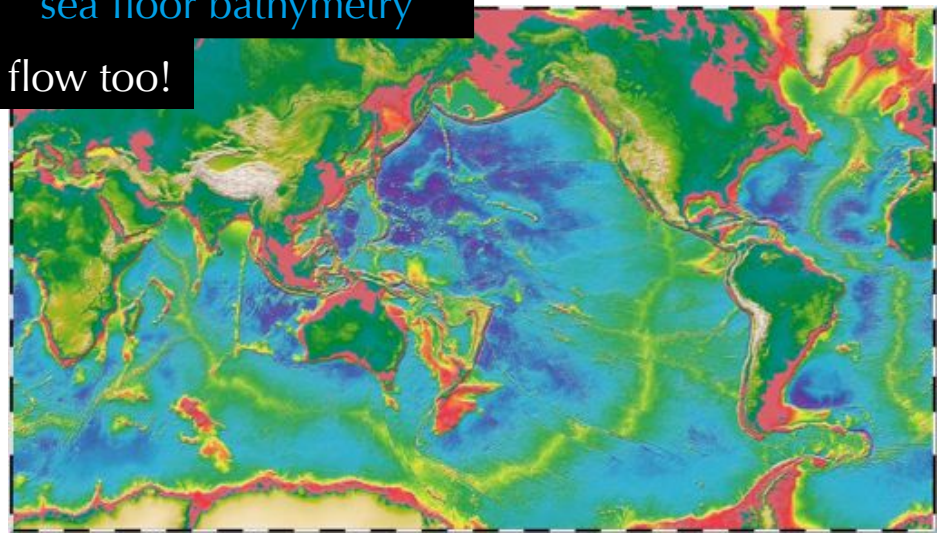
volcano locations

sea floor age

sea floor bathymetry

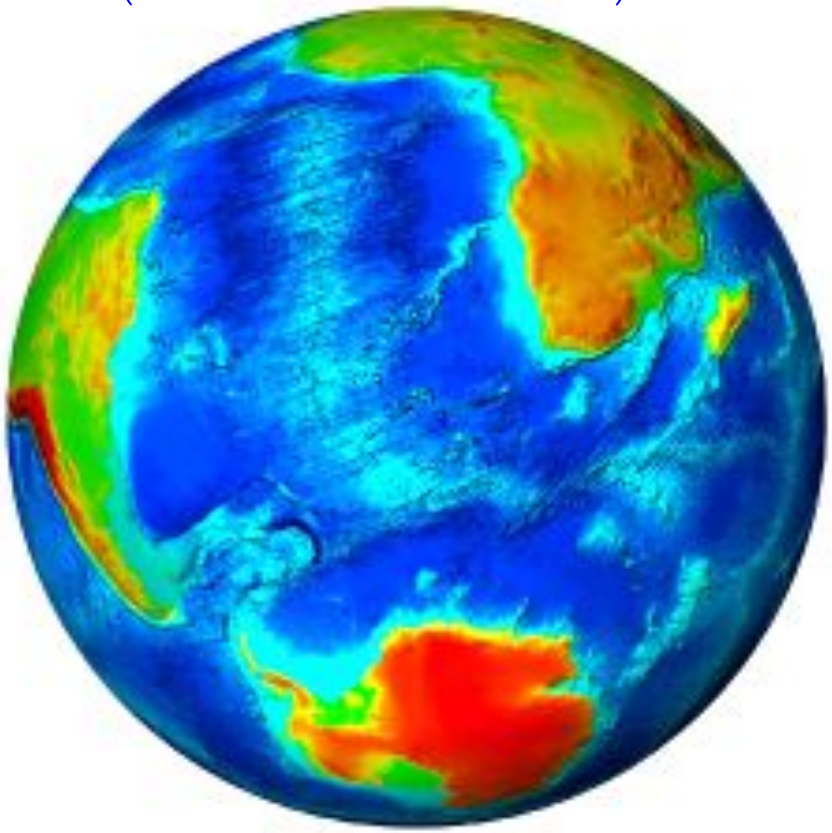
+ heat flow too!



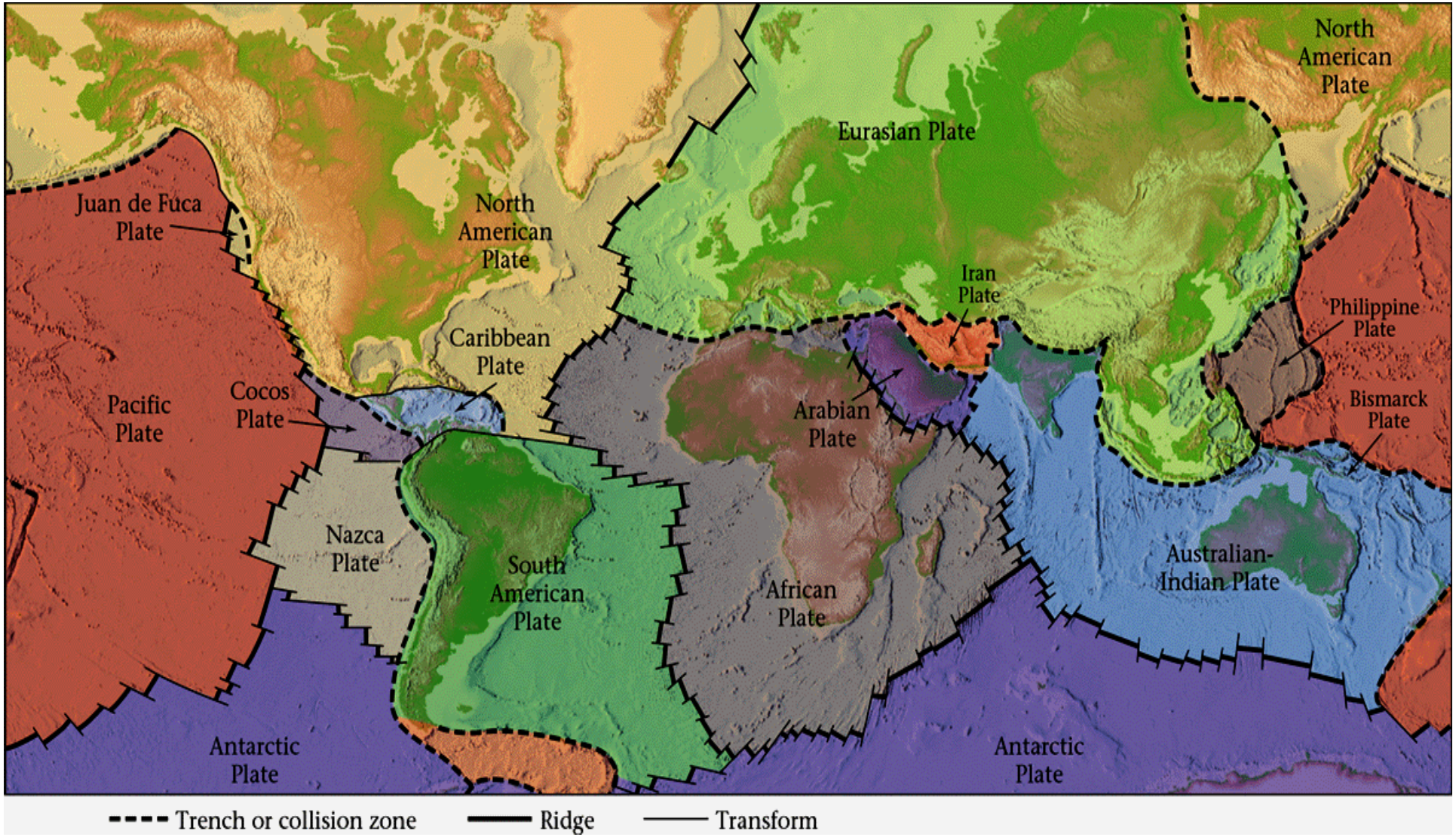


Critical Observations for Plate Tectonics Hypothesis

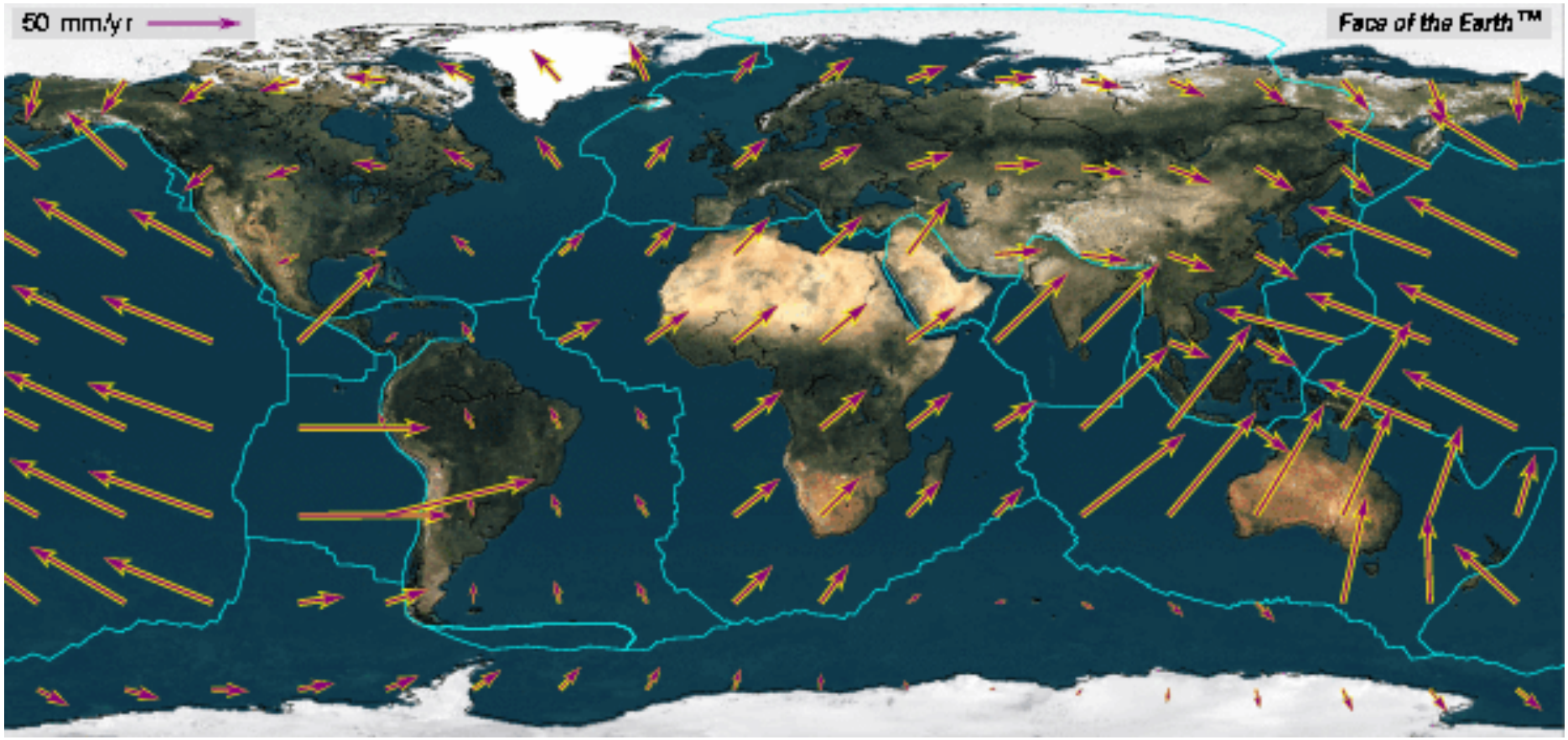
- Volcano and earthquake locations
- Wegner's observations of continental drift
- Reversals of Earth's past magnetic field (recorded in rocks)
- Bathymetry of the ocean floor
- Age of the ocean floor
- Heat flow from ocean floor



Earth's Major Plates



How Fast do the Plates Move?



Typical Plate Speeds

Atlantic Basin:	1-2 cm/yr
Indian Basin:	3-7 cm/yr
Pacific Basin:	5-10 cm/yr

Action Items for Thursday, Oct. 1

1. Read Chapter 3-2 to 3-4
2. Complete homework assignment #9

What you should know from today:

1. Describe the origin and recycling of oceanic crust
2. Identify the evidence that the polarity of Earth's geomagnetic field has reversed in the past
3. Describe the additional evidence that supports the theory of plate tectonics