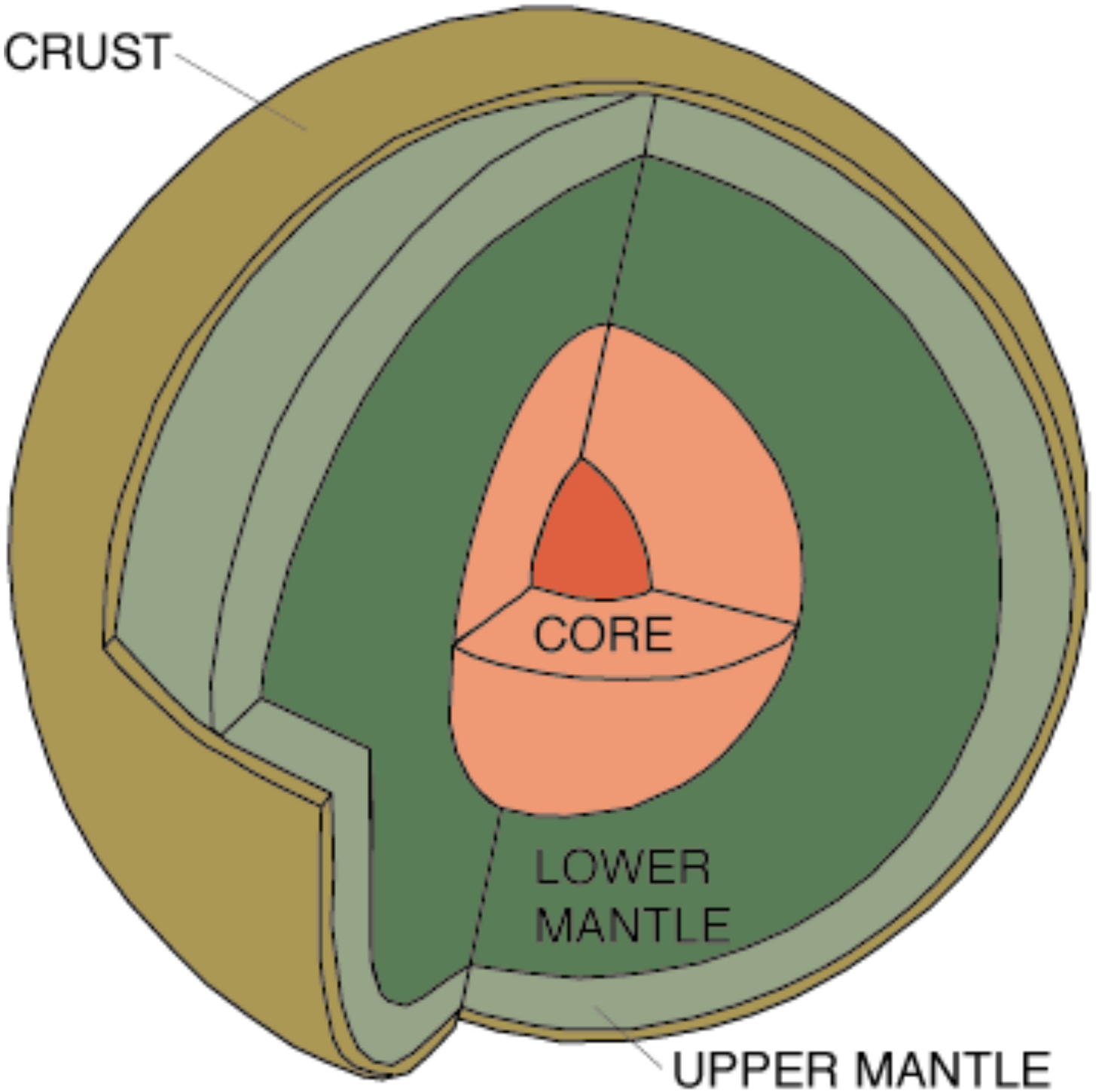
What Happens When You Dig Straight Down?

The deepest humans have dug:

- **12,262 meters deep! (~12 km)**
- The **Kola Superdeep Borehole** built in Russia by the Soviet Union, beginning in 1970.
- The project was to dig through the Earth's crust.
- Drilling stopped in 1989, at **12,262 meters** deep.

- @ 12,262 m, the temp was **180'C.**

HOT


CRUST
CORE
LOWER
MANTLE
UPPER MANTLE


SPL

Wait! How do we know the Earth really **is** a sphere?

Wait! How do we know the Earth really **is** a sphere?

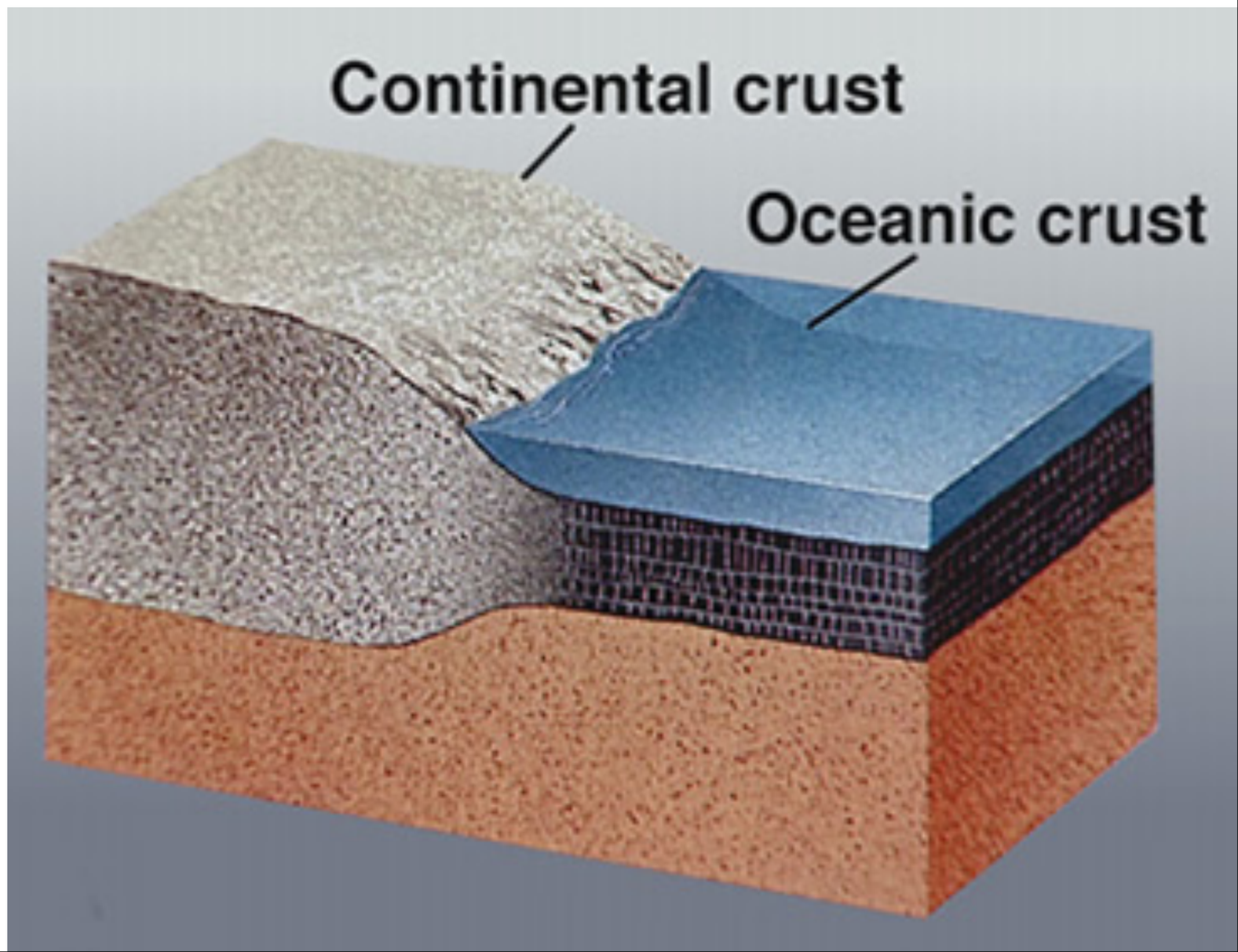
- **Proofs that the Earth is Round:**
  - Ships appearing to sink as they go over the horizon.
  - The Earth's shadow on the moon during an eclipse is always curved. This could only be possible if the Earth was a sphere.
  - Different time zones.
  - Different angles to Polaris as you travel N. or S.
  - Photos from space- the best proof.

The Earth is divided into four layers

1. The CRUST
2. The MANTLE
3. The OUTER CORE
4. The INNER CORE

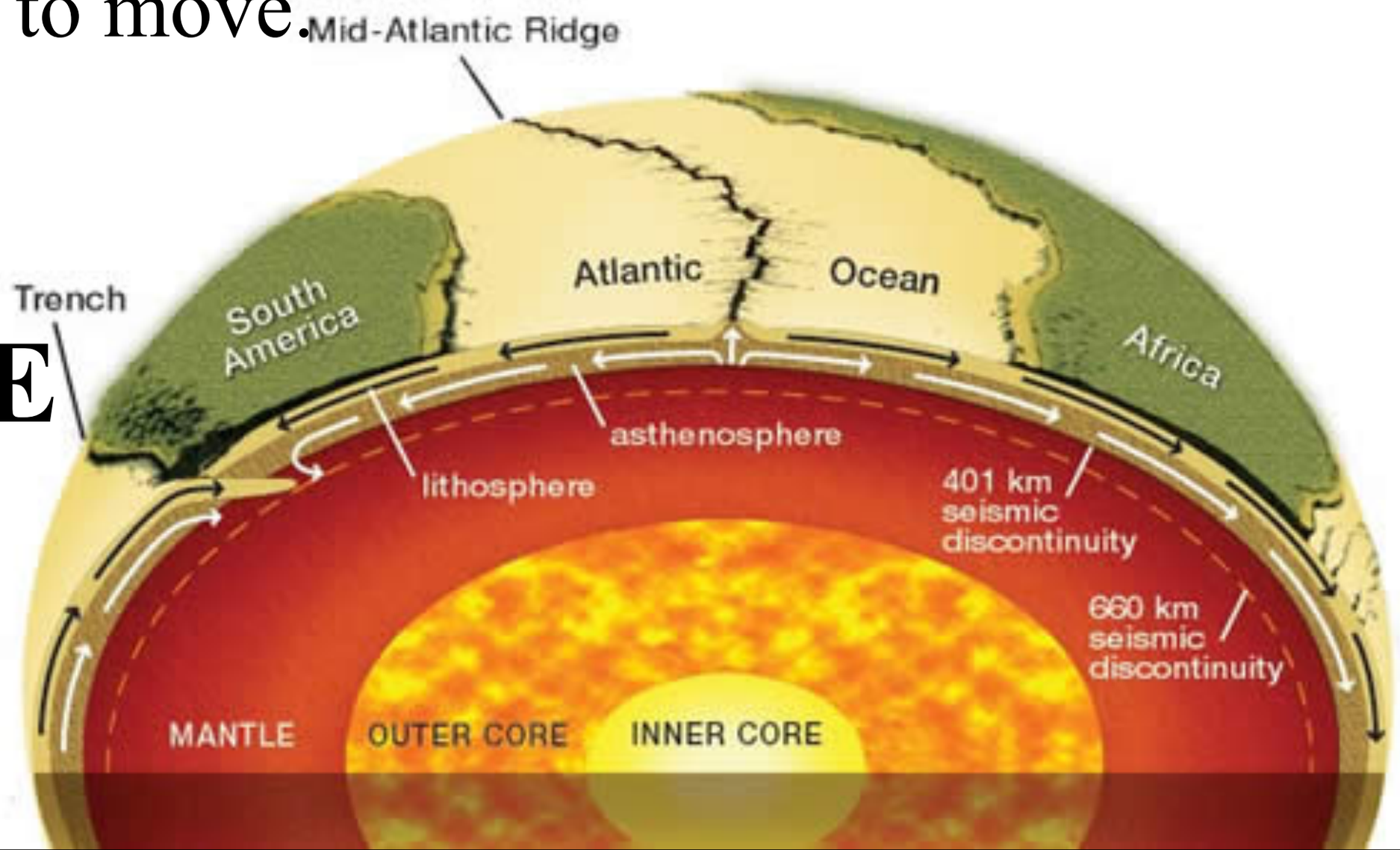
- There are two types of Crust:
  - a) **Continental Crust** (30 – 50 km thick)
    - Less dense rocks (eg. granite, sandstone)
  - b) **Oceanic Crust** (5 – 10 km thick)
    - More dense rocks (eg. basalt, gabbro)

The CRUST



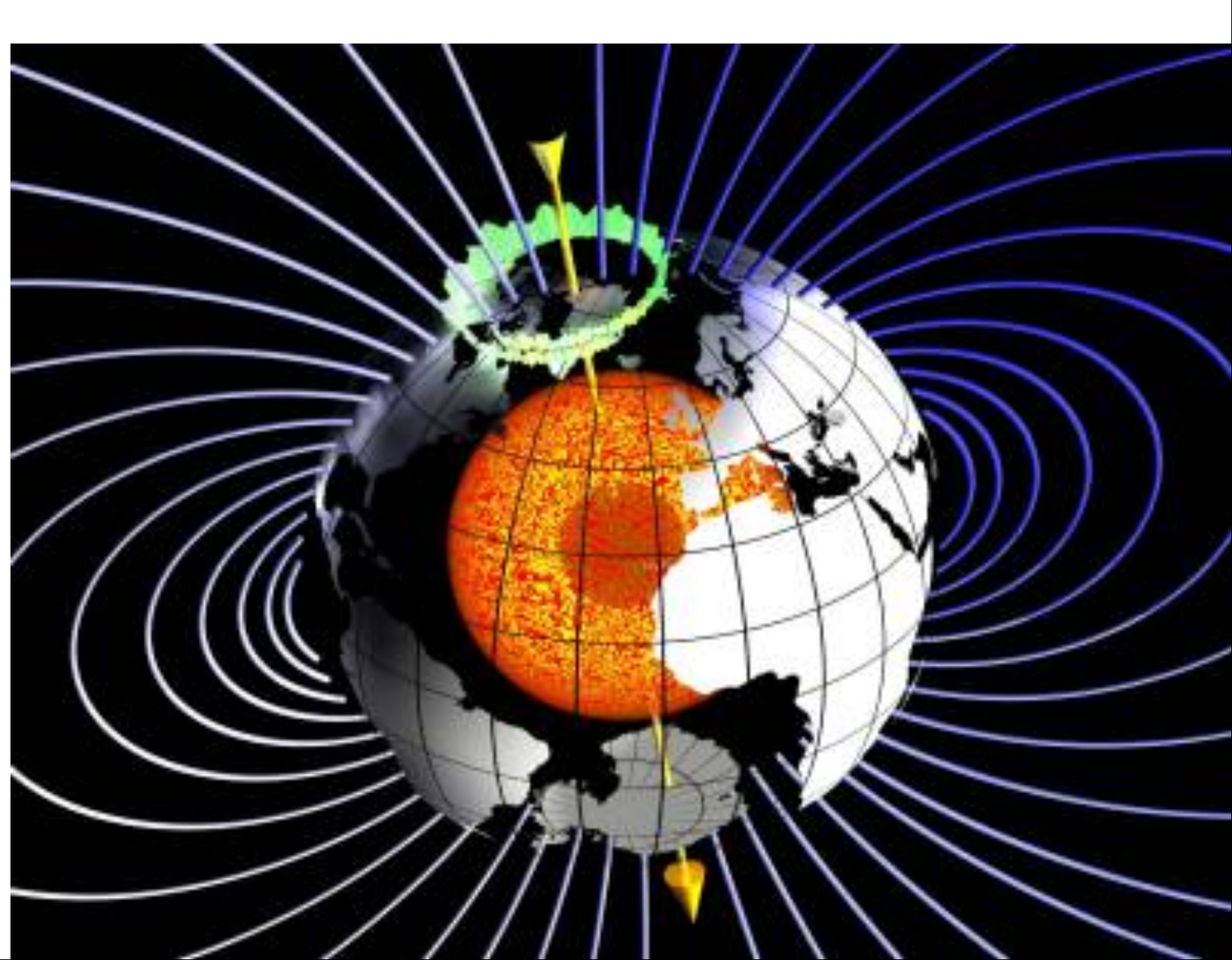
- The Mantle is a plastic layer of rocks and magma about 2900 km thick.
- Over 1000’C.
- The Crust ‘floats’ on the Mantle.
- Convection within the Mantle cause the plates to move.

The MANTLE



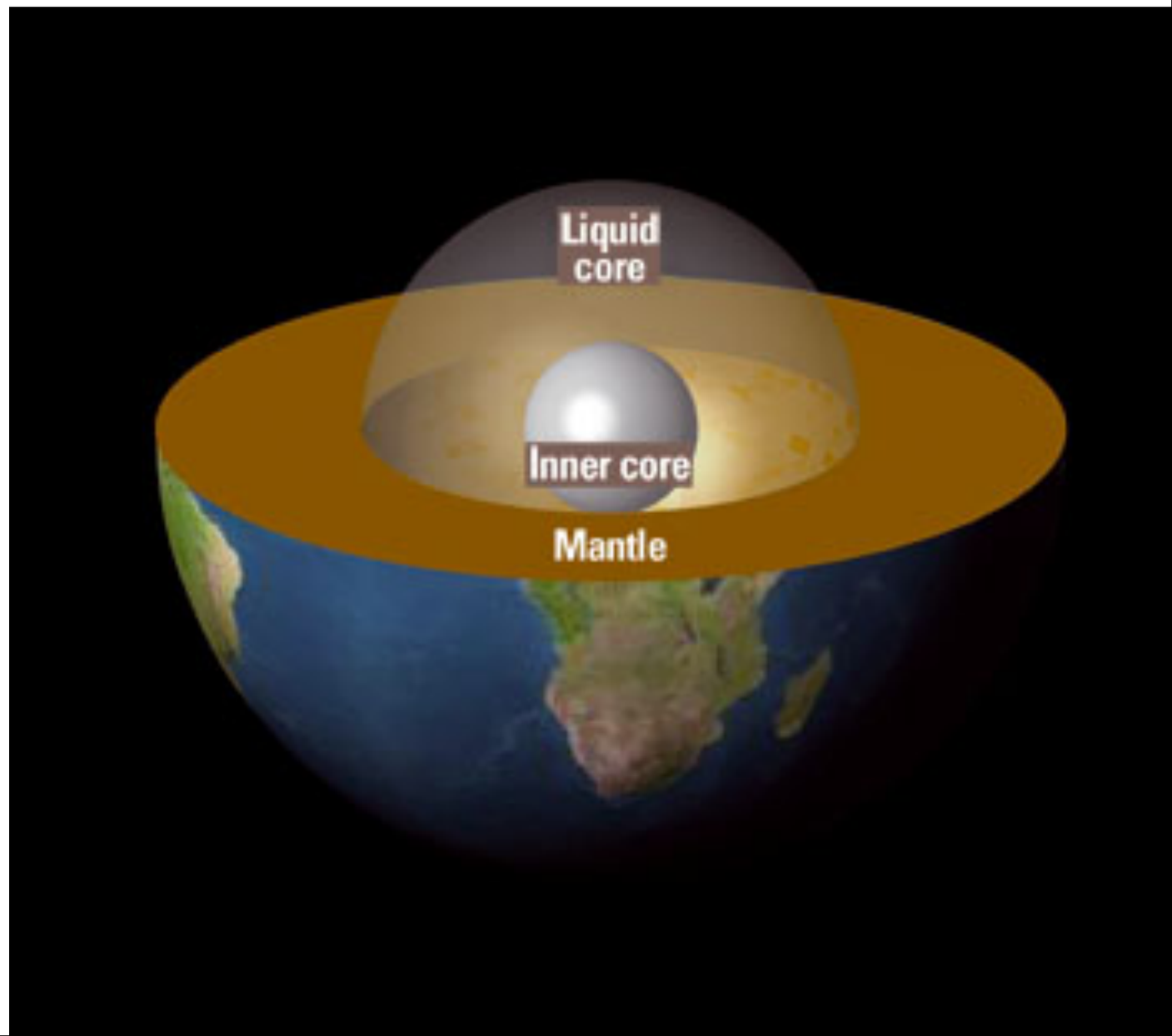
- The Outer Core is molten liquid iron.
- 2900 to 5000 km deep
- Over 4000’C
- Convection in the Outer Core (along with the rotation of the Earth) creates Earth’s Magnetic Field.

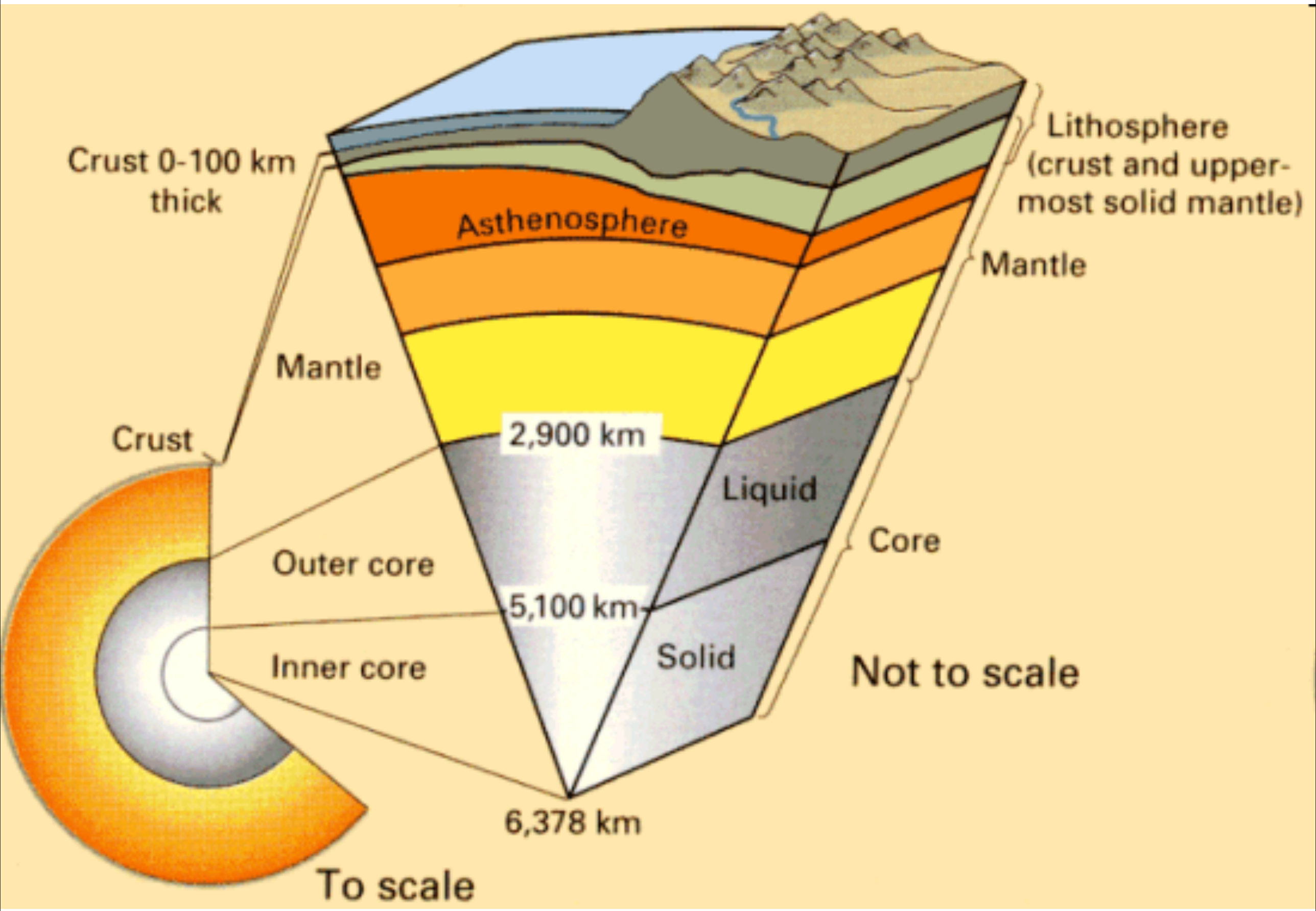
The OUTER CORE



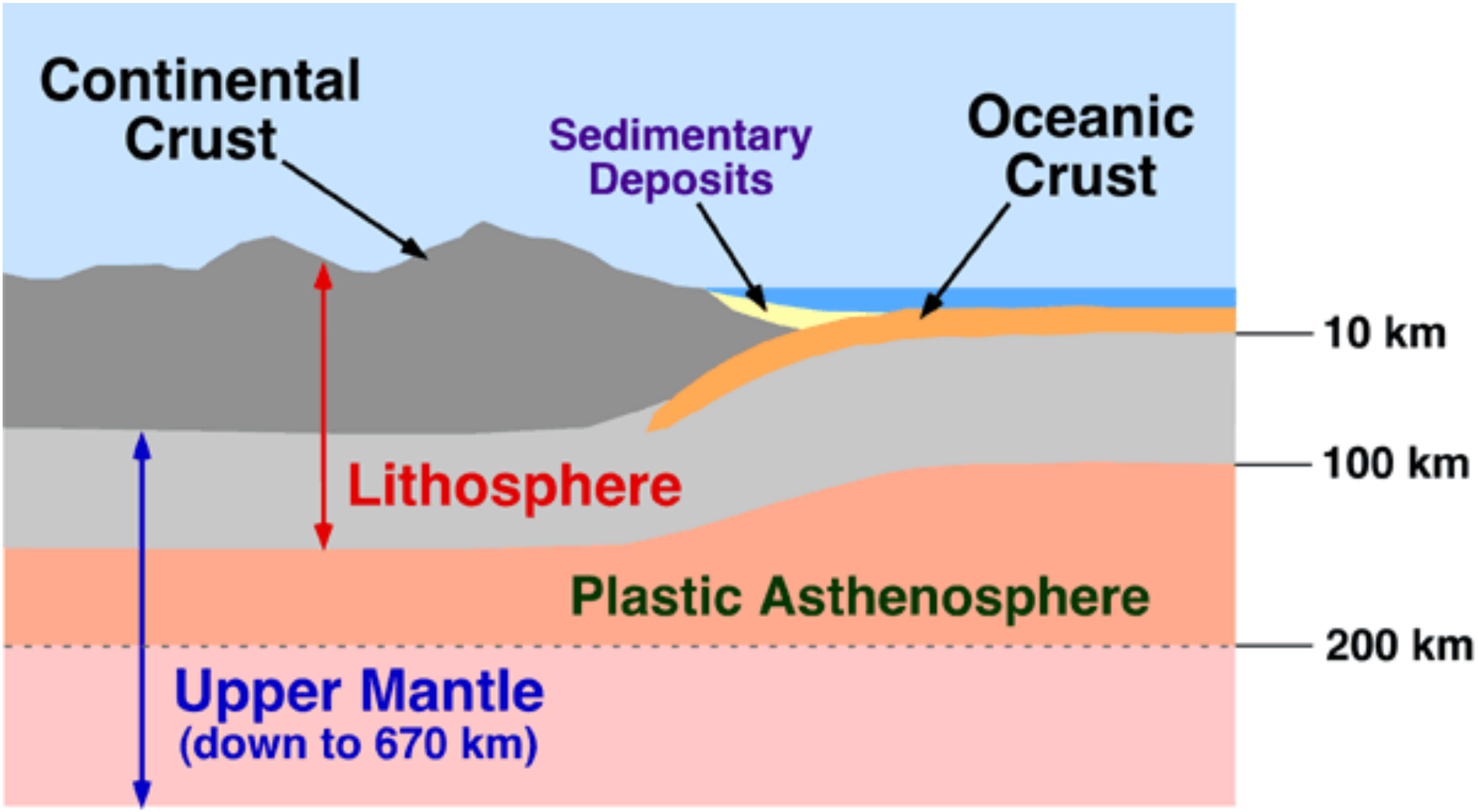
- A solid sphere of iron (and nickel), suspended in the liquid Outer Core.
- 5000 km to 6400 km deep.
- Over 5000’C. Very Hot!

The INNER CORE




Crust 0-100 km thick
Asthenosphere
Lithosphere (crust and upper-most solid mantle)
Mantle
Mantle
Crust
2,900 km
Liquid
Core
Outer core
5,100 km
Inner core
Solid
Not to scale
6,378 km
To scale

Review


Continental Crust
Sedimentary Deposits
Oceanic Crust
10 km
100 km
200 km
Lithosphere
Plastic Asthenosphere
Upper Mantle
(down to 670 km)

WE NEED A UNIFYING THEORY

- We know the **structure** of the Earth…
- We know **earthquakes** happen…
- We know **volcanoes** happen…
- We know **mountains** and **oceans** exist…

but **WHY?**

Alfred Wegener
had an idea
-1912-

Hmm, the continents look like they can fit together like a jigsaw puzzle!

They must have originally been there, then moved! They drifted away!

I know! **CONTINENTAL DRIFT!**

Continental Drift

The **idea** that the continents were originally together and drifted away from each other.

Can you see any continent coastlines that fit together?

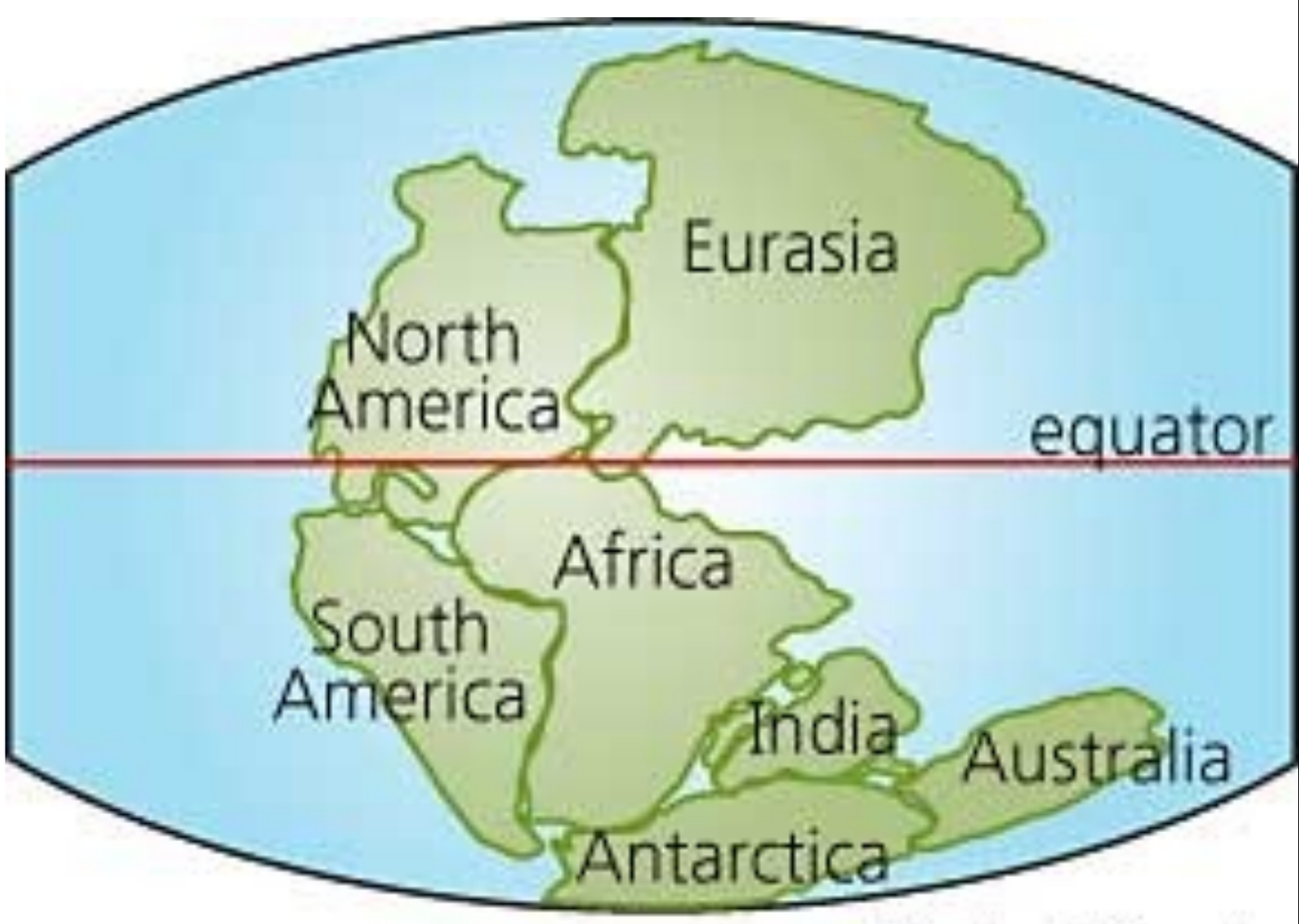
PANGEA

A Supercontinent

- Wergener invented the idea that all the continents were once joined together, in a supercontinent! **Pangea**!

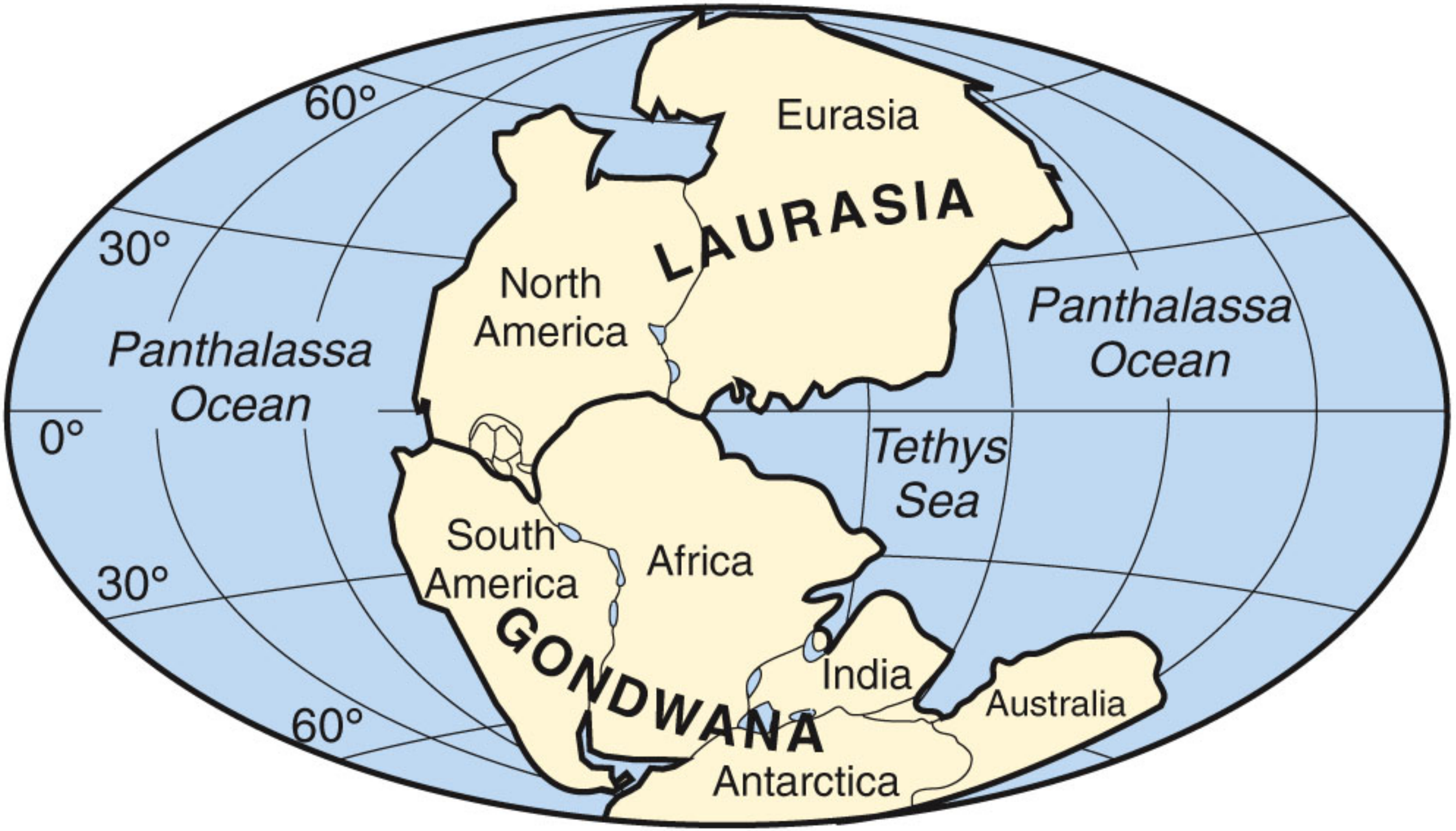
•<u>Supporting Evidence</u>:

1. JIGSAW COASTLINES




Africa
South America

Pangaea


60°
30°
0°
30°
60°
Panthalassa Ocean
Eurasia
LAURASIA
North America
Panthalassa Ocean
Tethys Sea
South America
Africa
GONDWANA
India
Australia
Antarctica

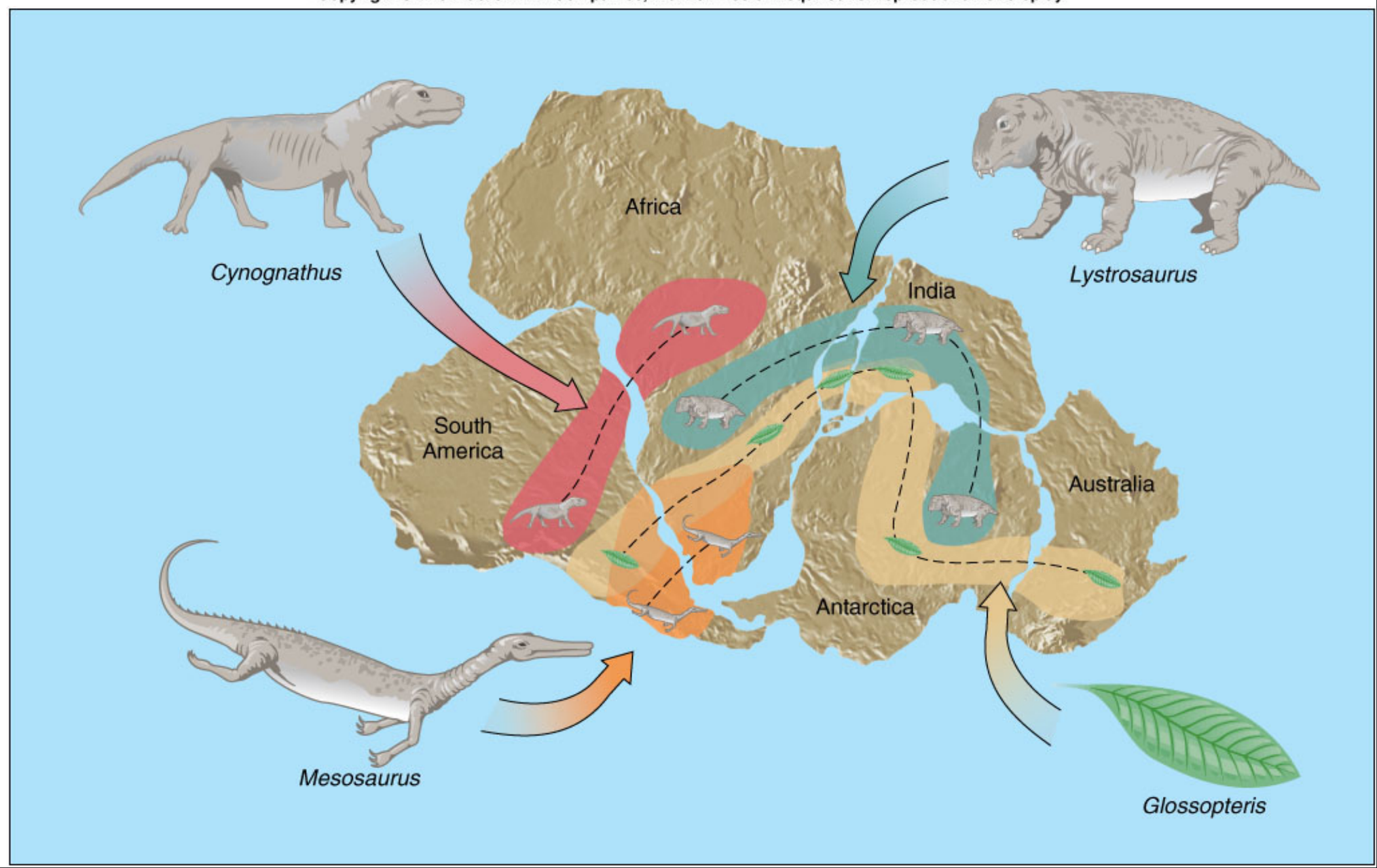
Pangea

(with modern countries)

Evidence for Continental Drift

2. FOSSIL EVIDENCE

- Fossils of animals are found in many different continents (which were connected in the past!)

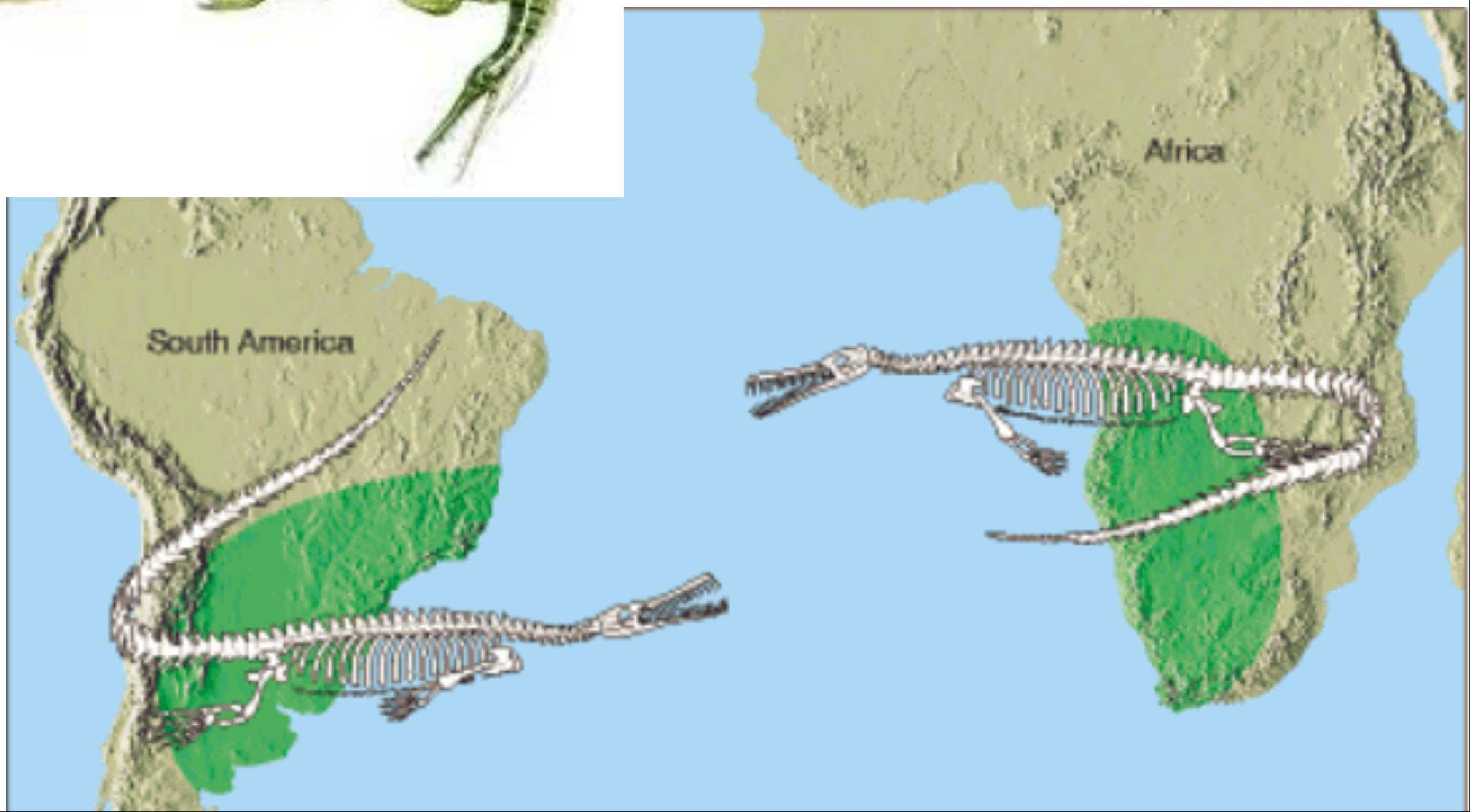


Eg: **Mesosaurus**

Fossils of this Permian marine reptile are found in South America and Africa.

-Did he swim across an ocean?

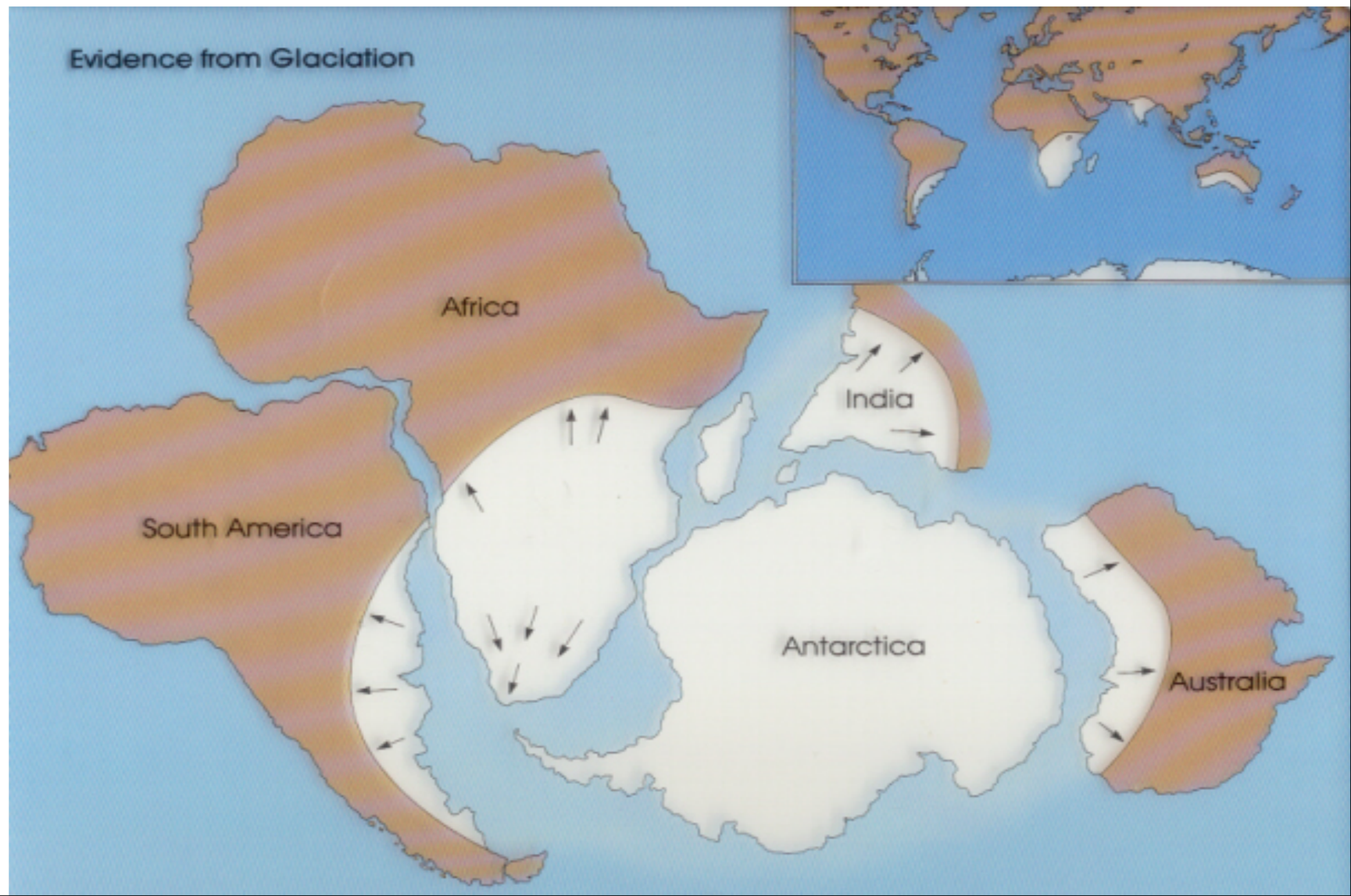
-Did one species of critter randomly evolve 3000 km apart?



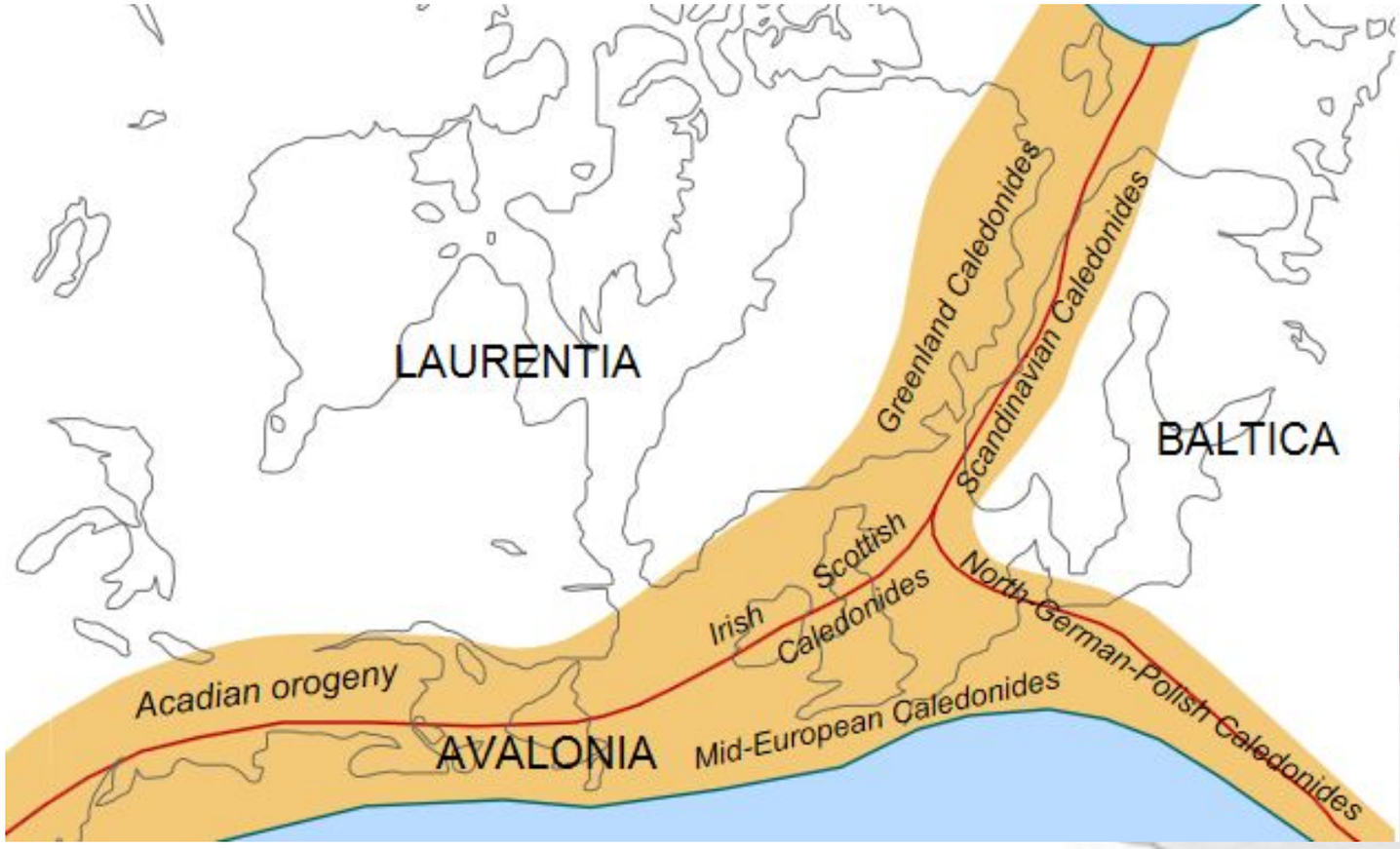
Evidence for Continental Drift

3. PALEO-GLACIATION

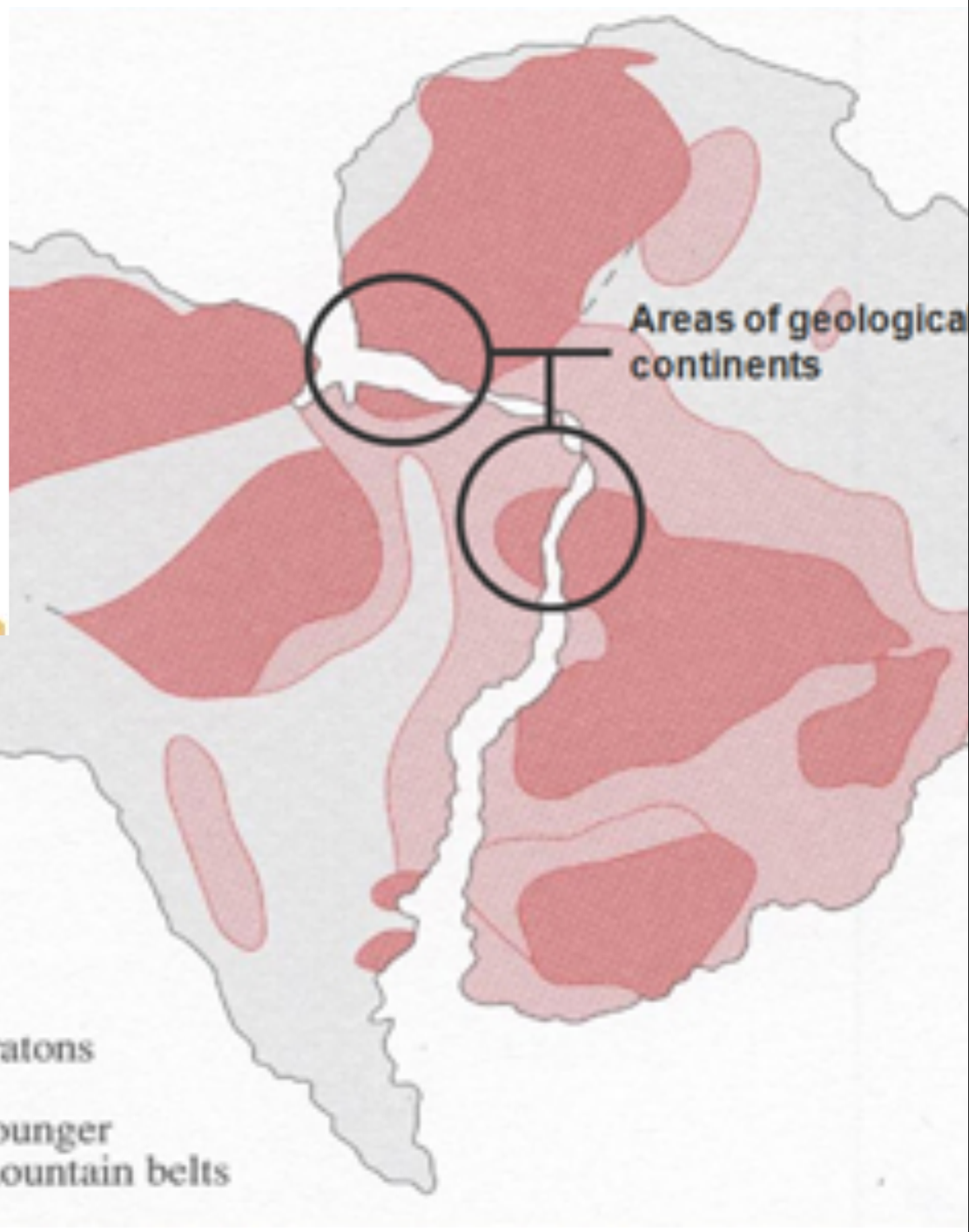
- Deposits from past glaciers in South America, Africa, Madagascar, Arabia, India, Australia, and Antarctica is evidence that they were once connected!



4. MOUNTAIN CHAINS



5. ROCKS (same Geology)



Reaction to Continental Drift...

In 1912, everyone rejected Wergener's theory.

*"**Not enough evidence!** Go back to meteorology!"*

"but HOW did the continents move?"

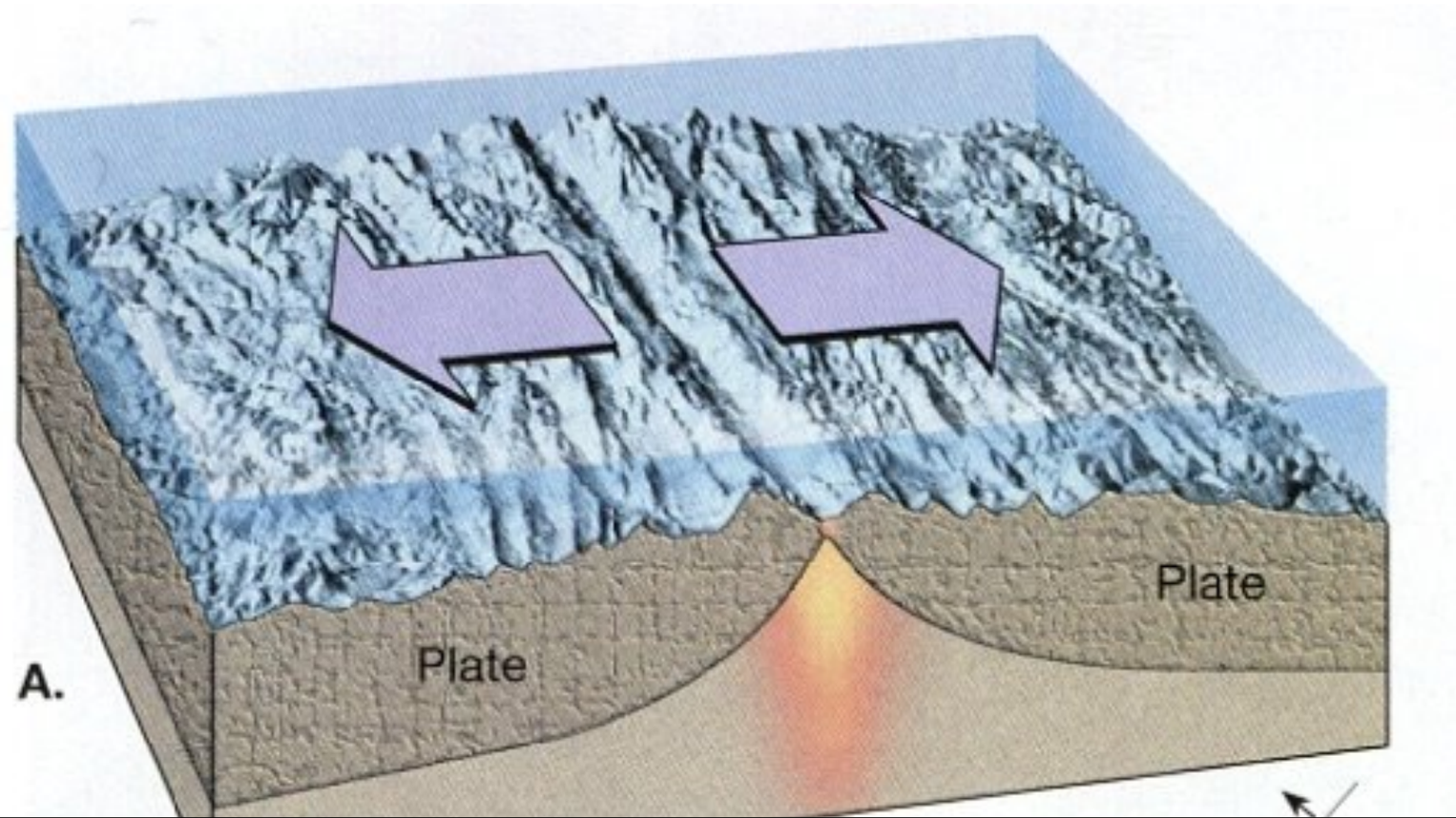
"Land bridges ftw!"

Debate over Continental Drift raged for decades, until more **evidence** led the way to the most ground-breaking theory in Earth Science…

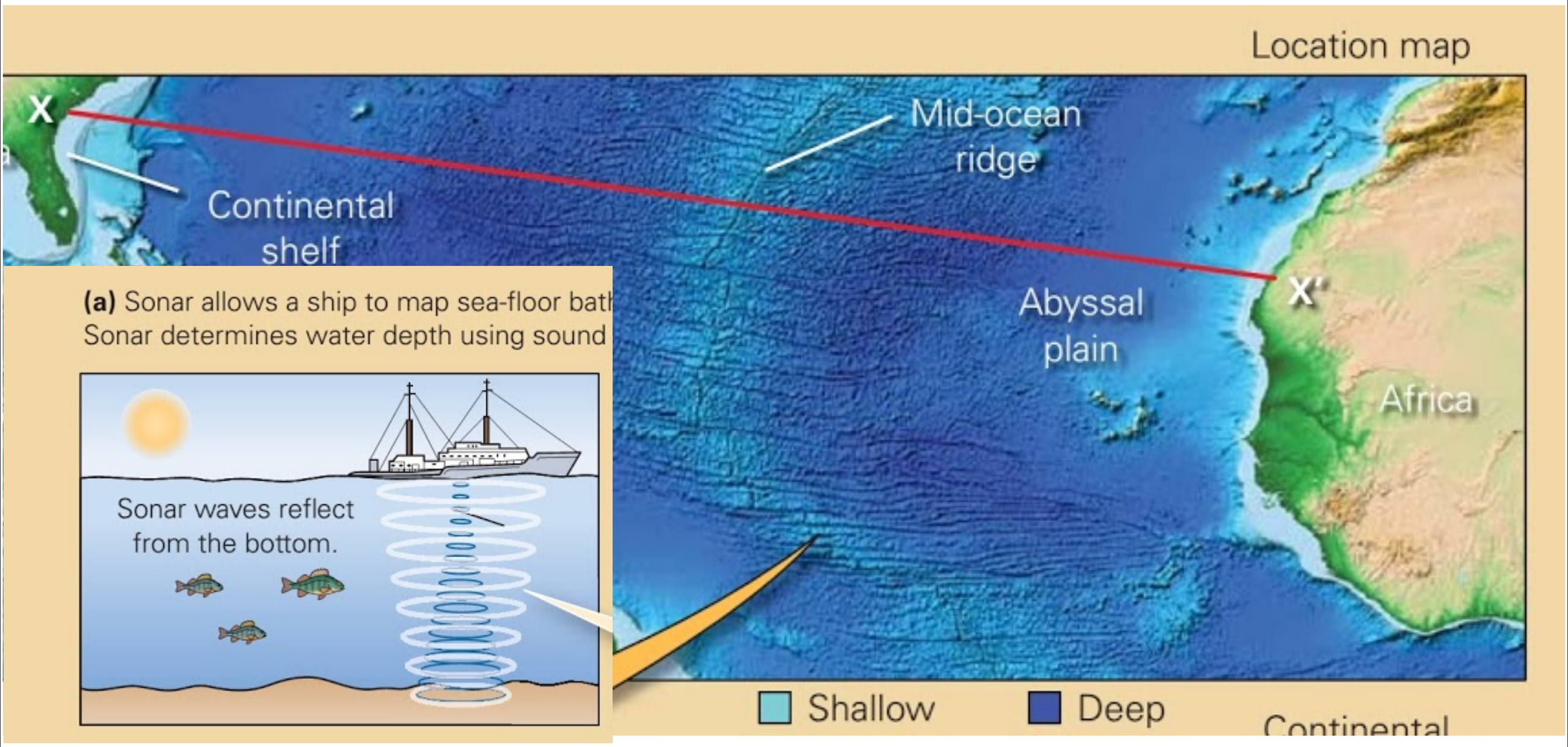
Evidence from **Sea-Floor Spreading**

SEAFLOOR SPREADING

- The study of the ocean floor intensified after WWII with **sonar**.
- Geologist and naval officer **Harry Hess** proposed the idea that not only do the continents drift, but the ocean floor does too!

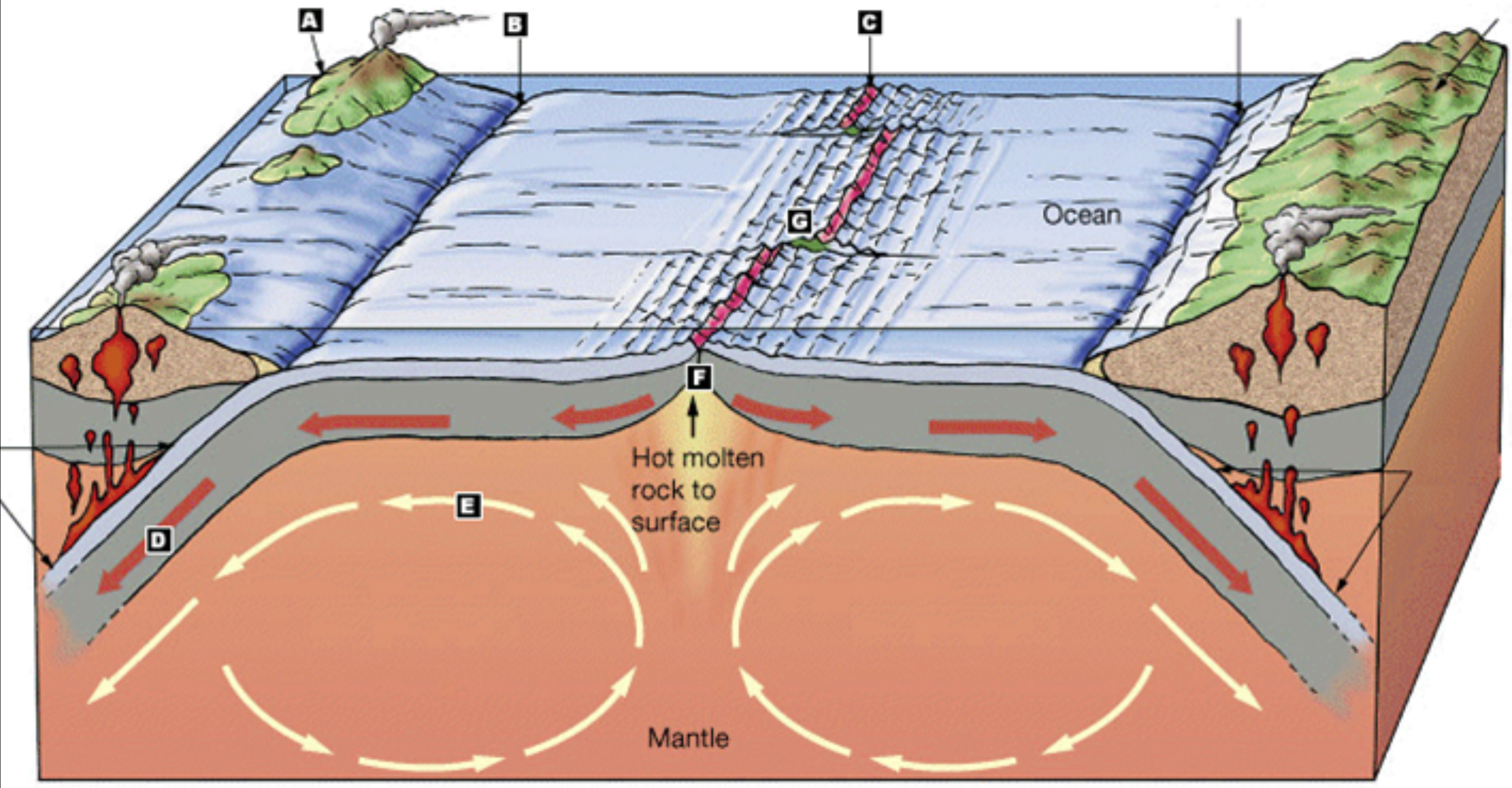


Mapping the Seafloor...



(b) A bathymetric profile along line X–X′ illustrates how mid-ocean ridges rise above abyssal plains. Both are deeper than continental shelves.

Seafloor Spreading (F)

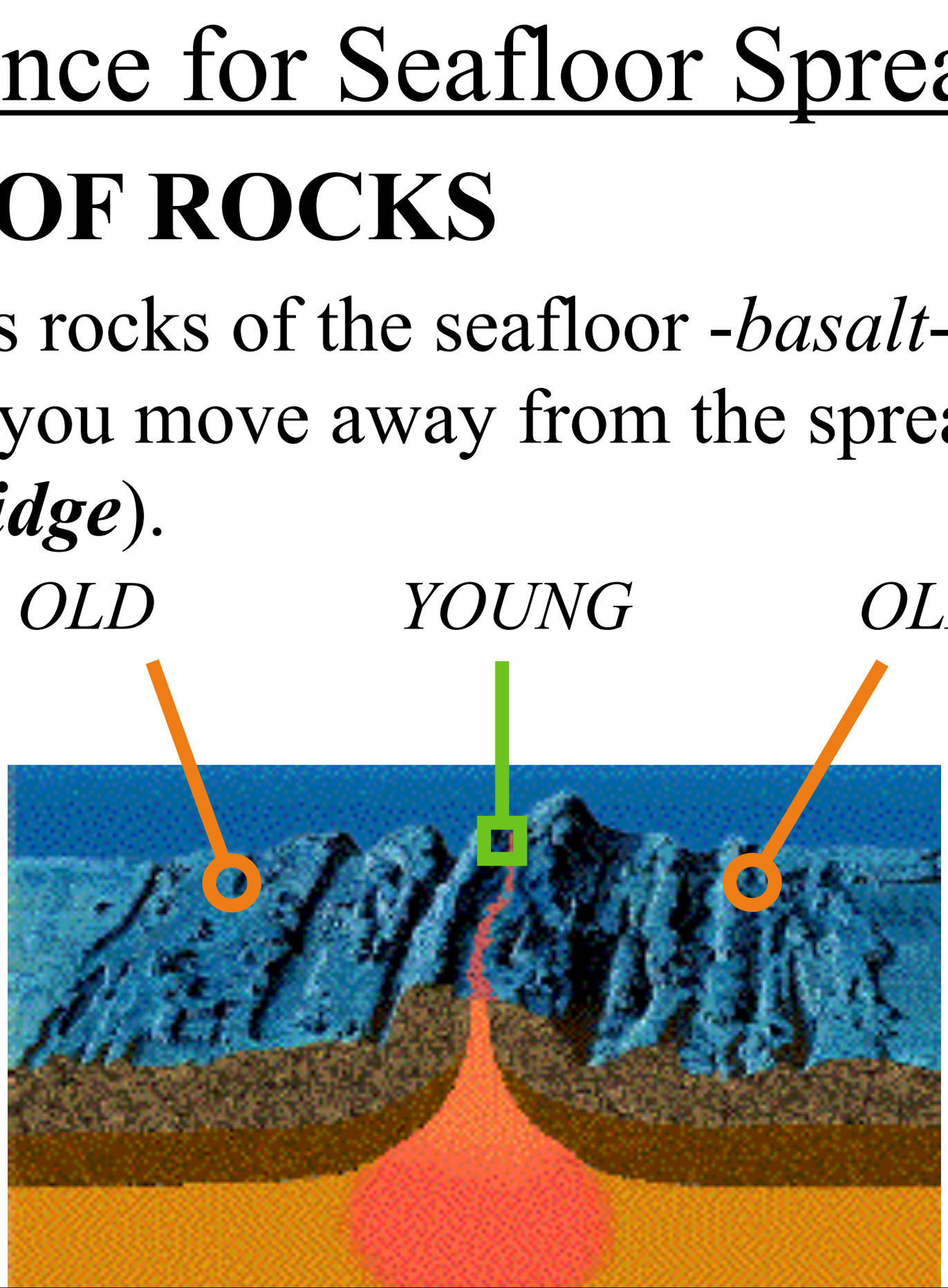


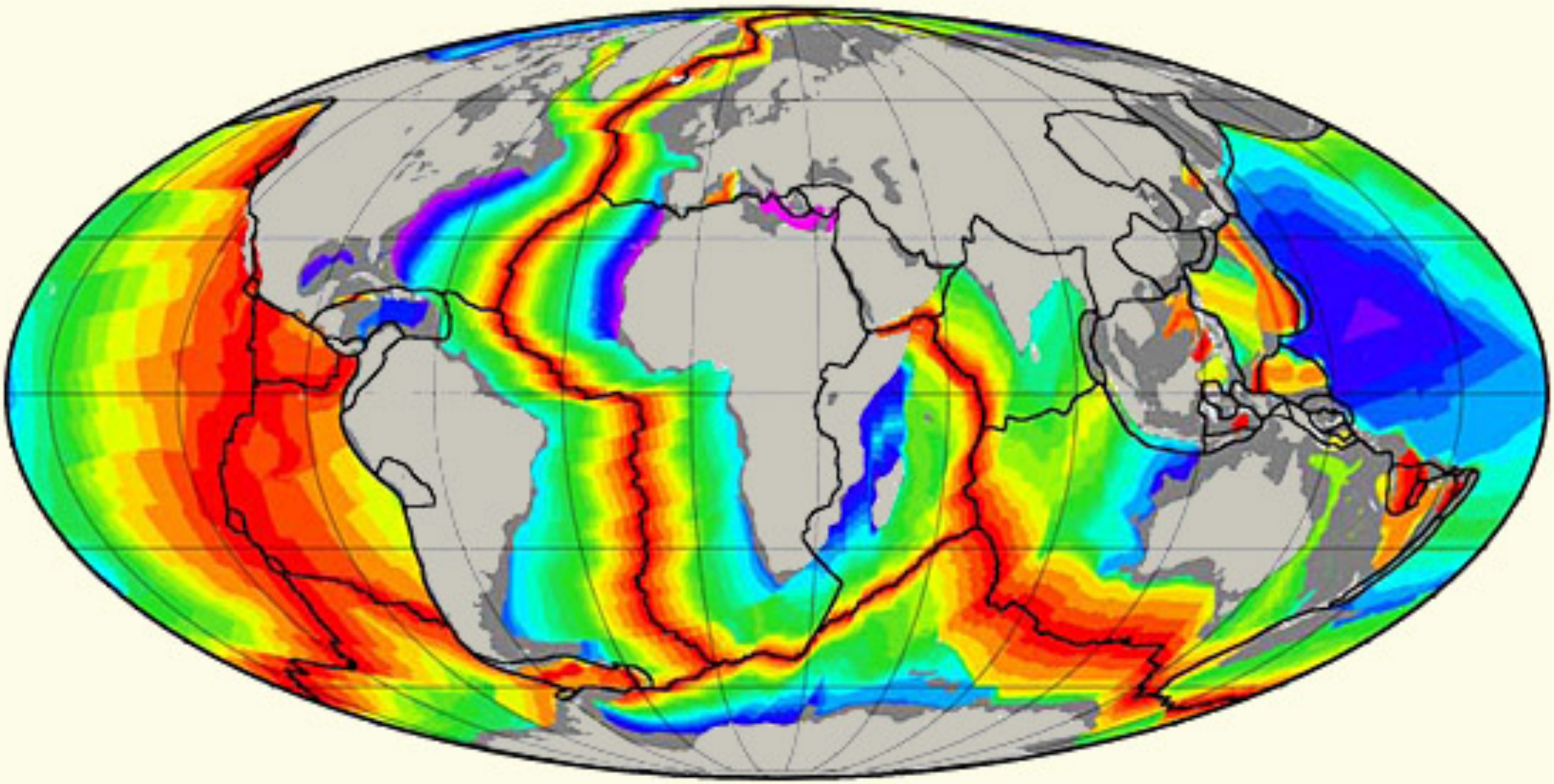
Evidence for Seafloor Spreading:

1. **AGE OF ROCKS**

The igneous rocks of the seafloor -*basalt*- get **older** as you move away from the spreading center (***ridge***).

OLD *YOUNG* *OLD*





Cenozoic | Cretaceous | Jurassic

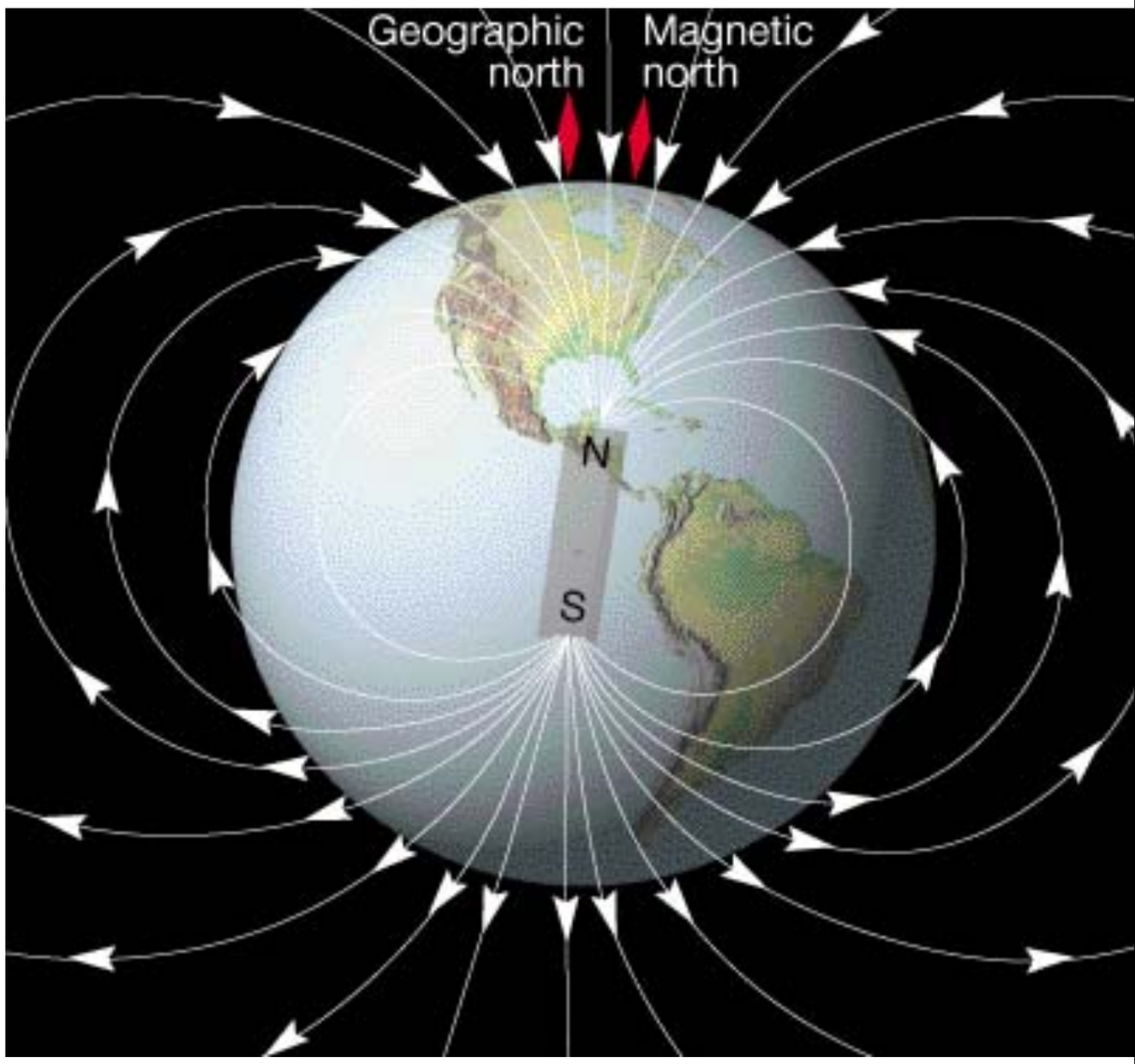
Modern ocean floors colour-coded by geological age

The crust either side of the spreading centres becomes progressively older. Note how the floor of the Pacific Ocean has been subducting eastwards under North and South America.

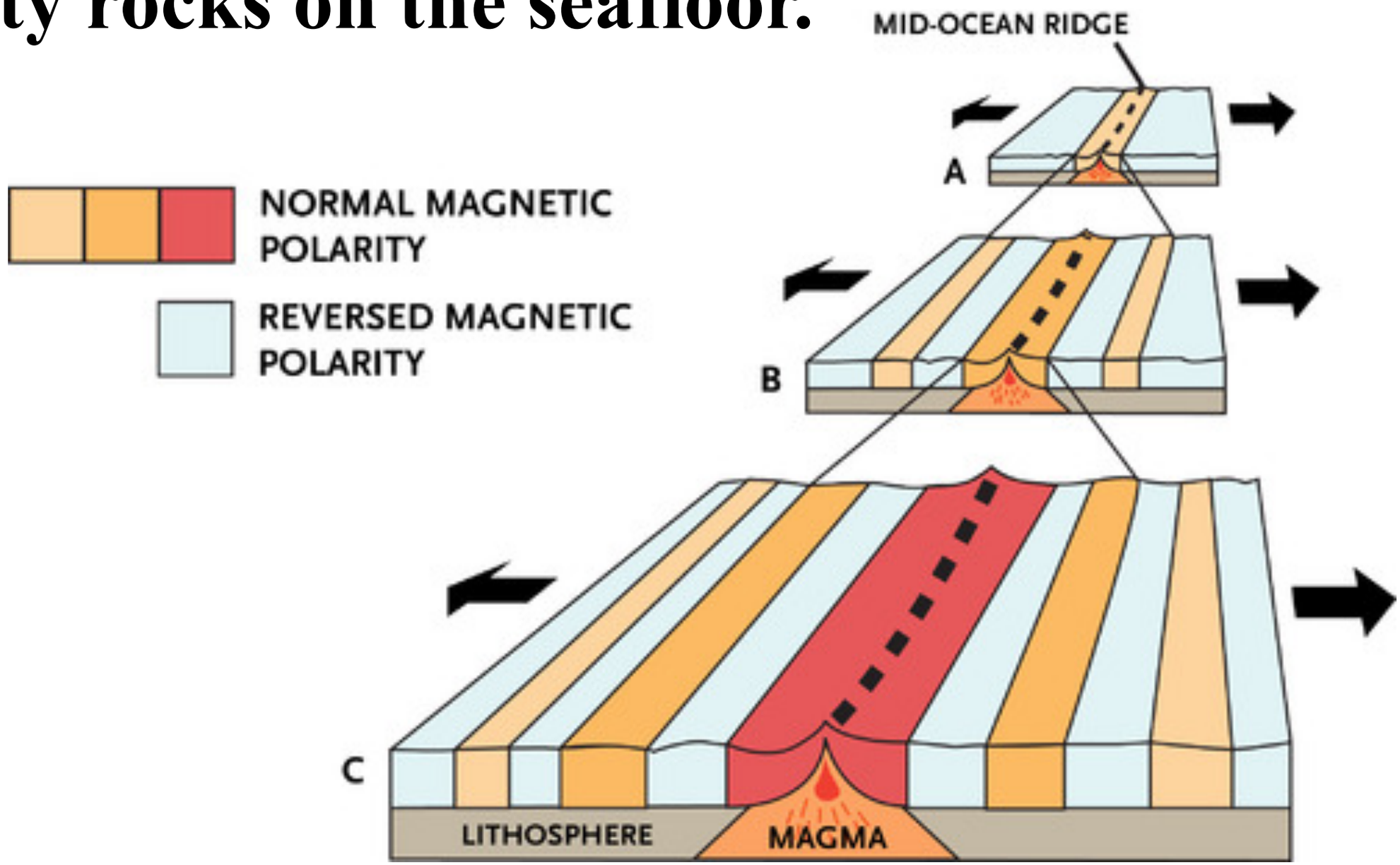
Evidence for Seafloor Spreading

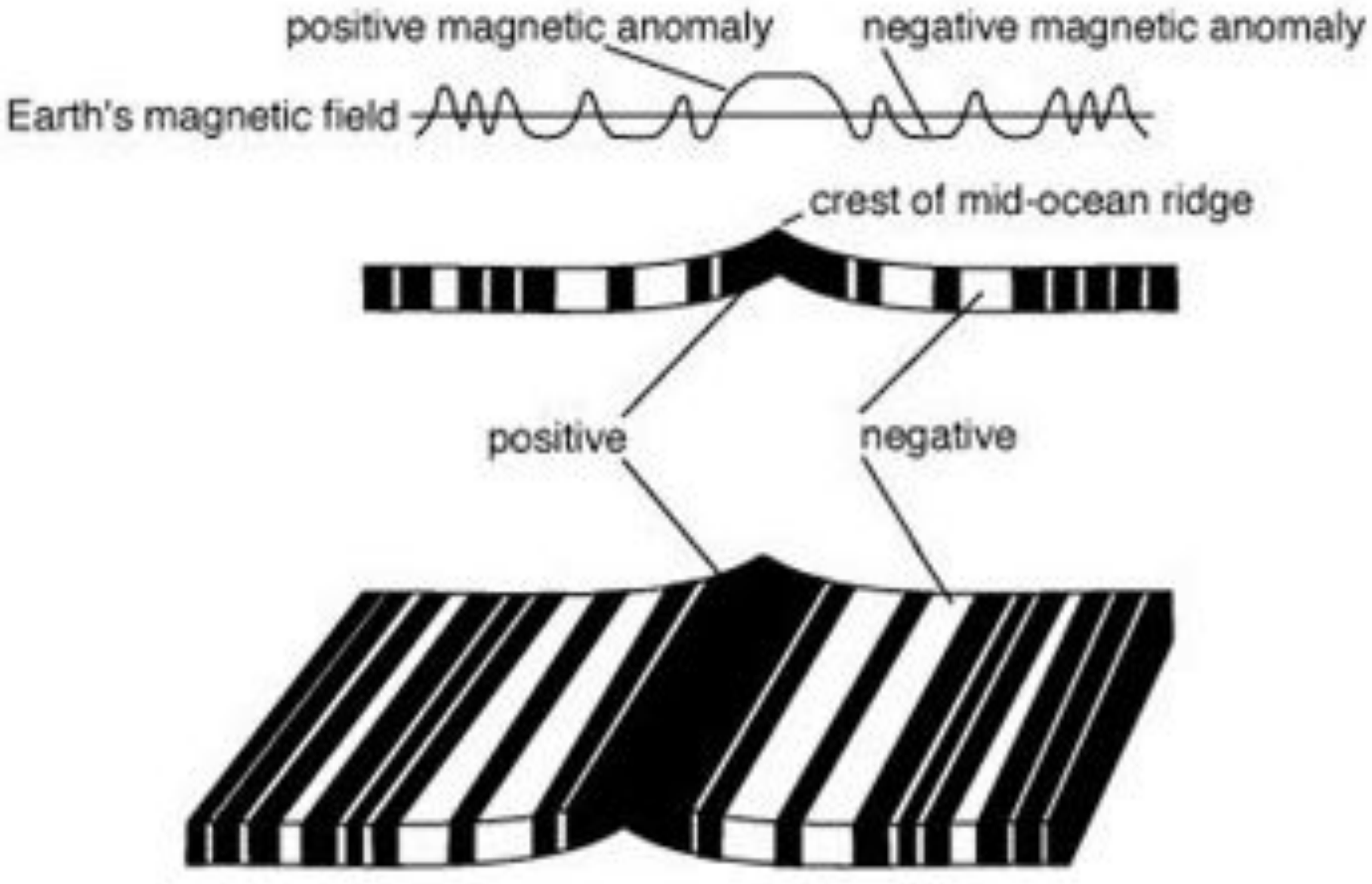
2. PALEOMAGNETISM
Vine-Matthews-Morley hypothesis (1963)

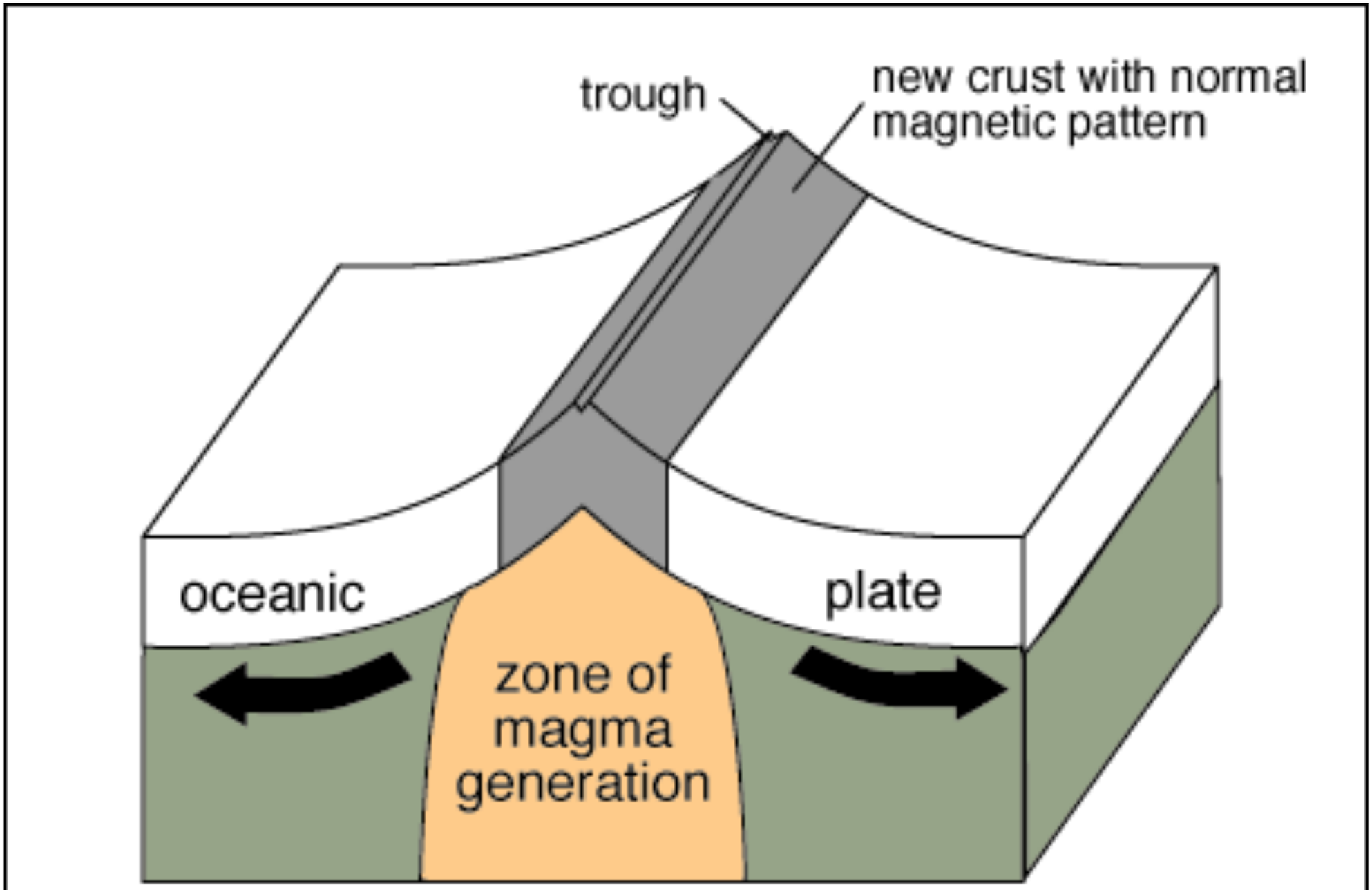
- Earth has a magnetic field generated by the flow of liquid metal in the Outer Core.
- Every so often (1-5 million years), magnetic field polarity **reversal** happens…



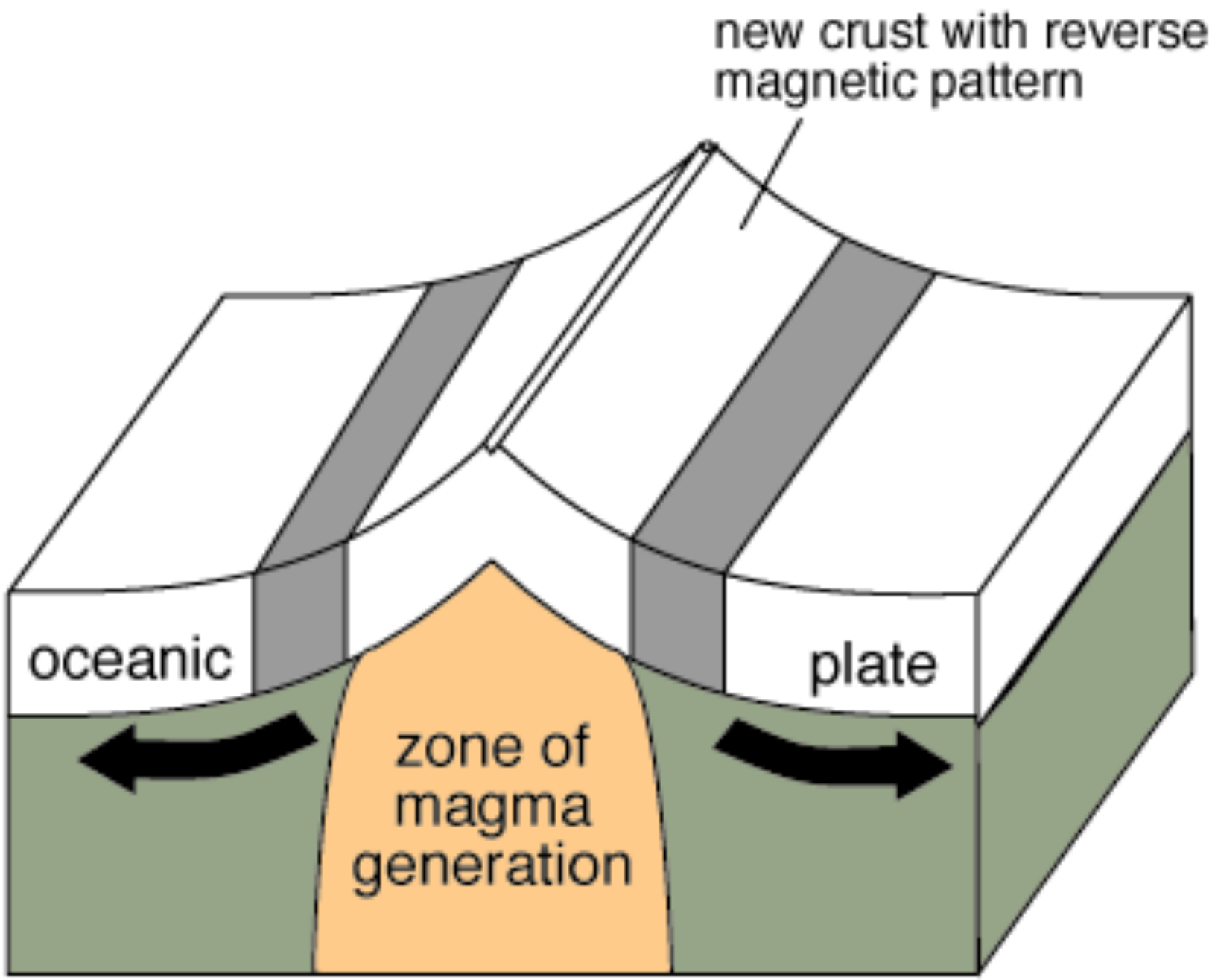
- …and the direction of polarity is locked into the igneous rocks (lava) when they form!
- As the polarity reversals happen, **bands of normal polarity rocks <u>alternate</u> with bands of reversed polarity rocks on the seafloor.**



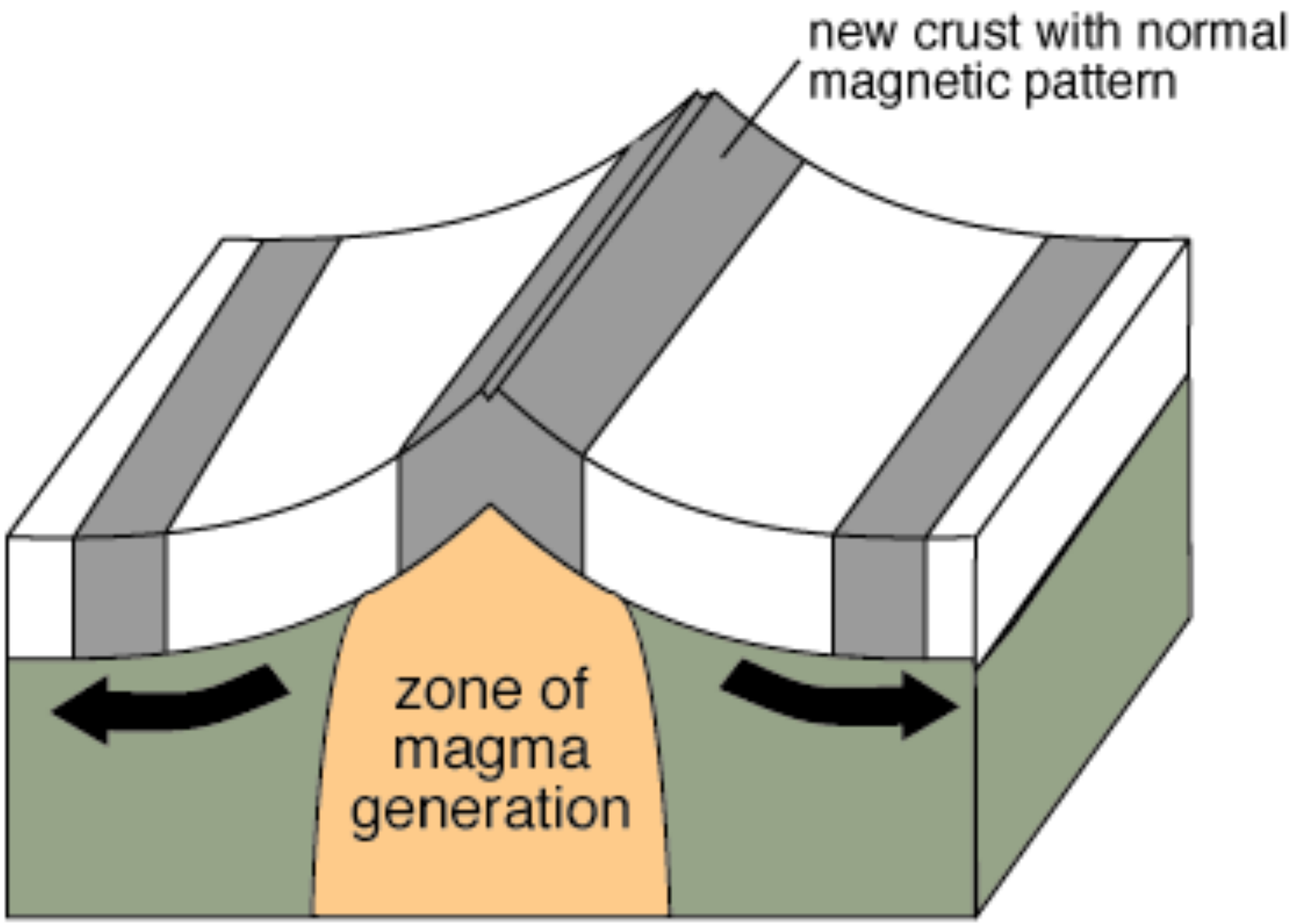

positive magnetic anomaly
negative magnetic anomaly
Earth's magnetic field
crest of mid-ocean ridge
positive
negative



As magma solidifies along the edge of the oceanic plate it preserves a magnetic record of the Earth's magnetic field at that time. In this case, the north magnetic pole is in the northern hemisphere.



If the magnetic pole is in the southern hemisphere, the rocks record a reverse magnetic pattern.



At the present time, rocks record a normal pattern because the north magnetic pole is in the northern hemisphere.

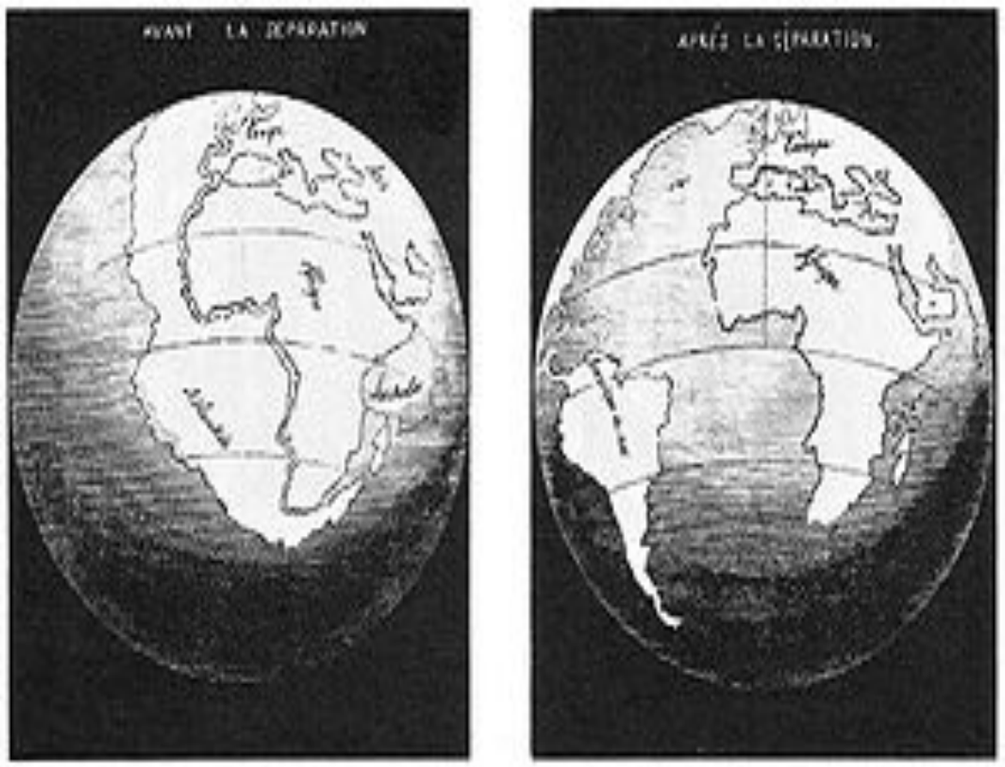
Evidence from **Continental Drift** and **Seafloor Spreading** led the way to the most ground-breaking theory in Earth Science…

PLATE TECTONICS!

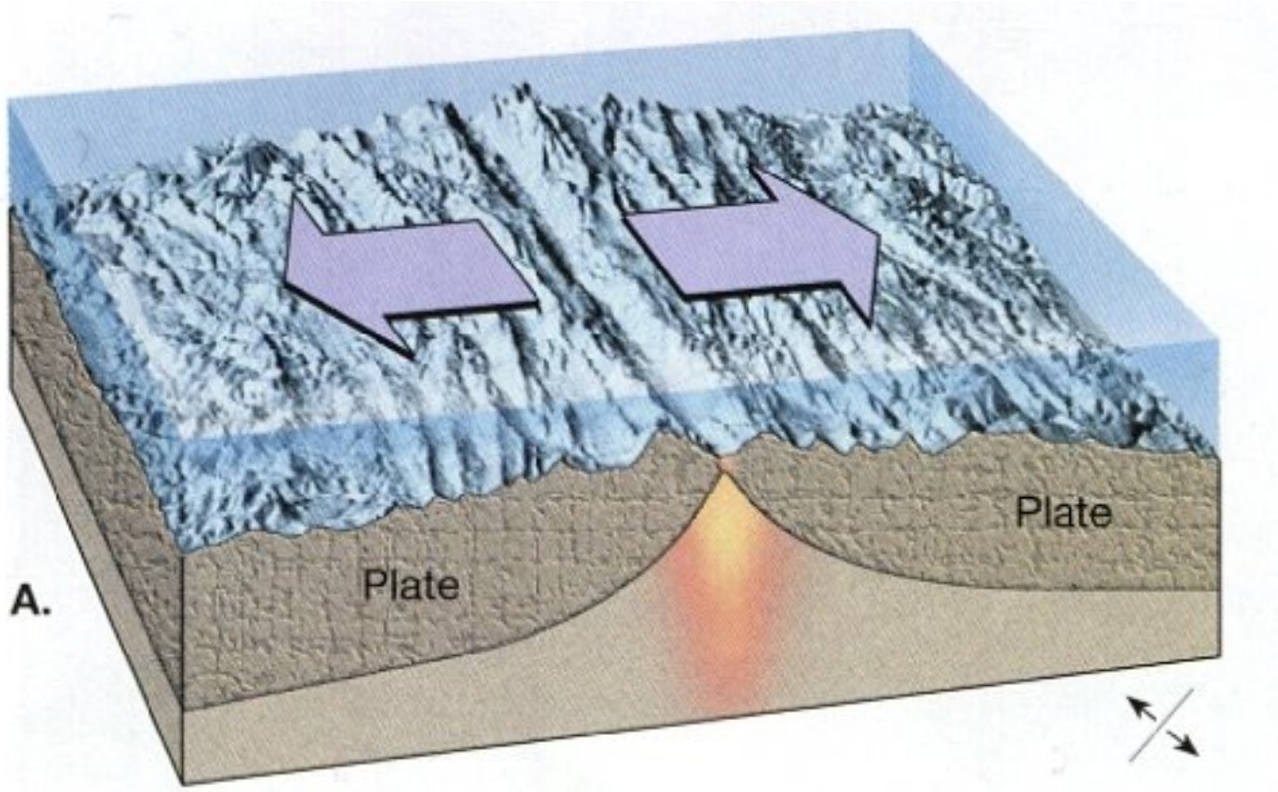
(published in 1965)

History of Plate Tectonics

- In the 1960's, the old idea of **Continental Drift** was merged with the new idea of **Seafloor Spreading** to create a new, unifying theory – <u>Plate Tectonics</u>!



+



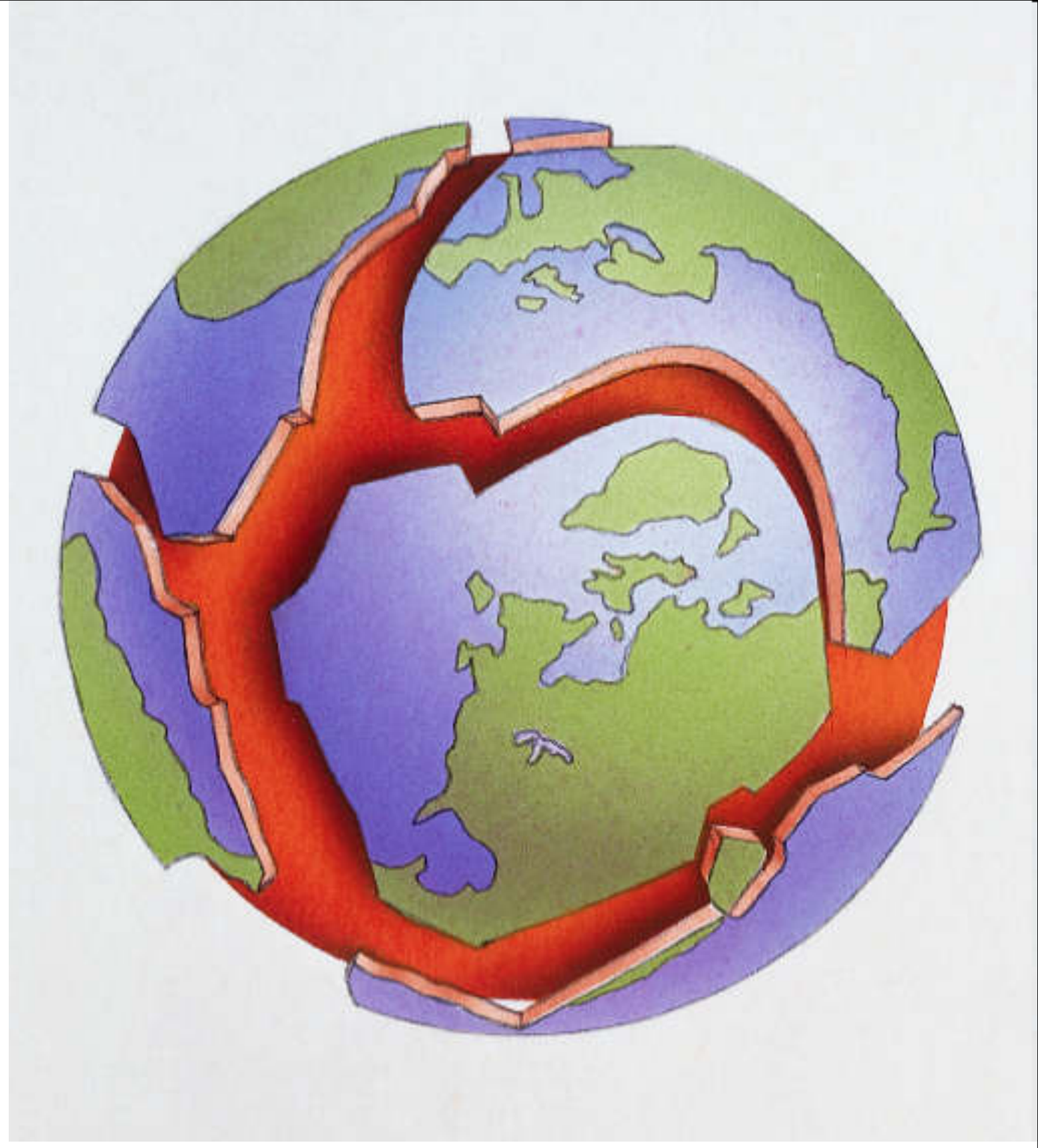
Continental Drift + Seafloor Spreading = <u>Plate Tectonics</u>

The Theory of Plate Tectonics

A. The surface of the Earth is divided into large **tectonic plates**.

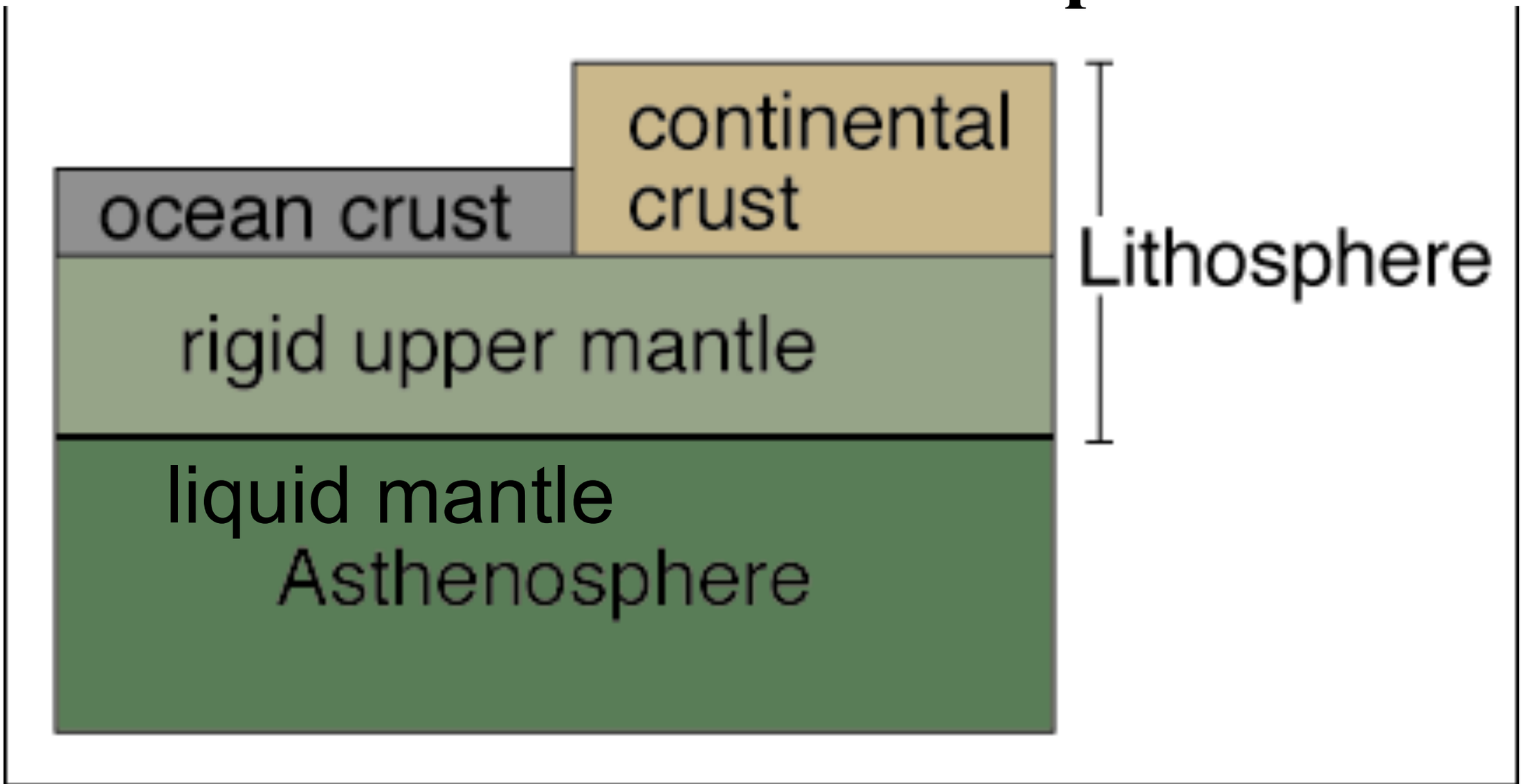
B. These tectonic plates are **always moving**.

C. Movement at the **plate boundaries** create features, such as <u>mountains, ocean trenches, volcanoes and earthquakes</u>.



What is a ‘Plate’?

- A plate is a large piece of the **lithosphere**, which 'floats' on the **asthenosphere**.

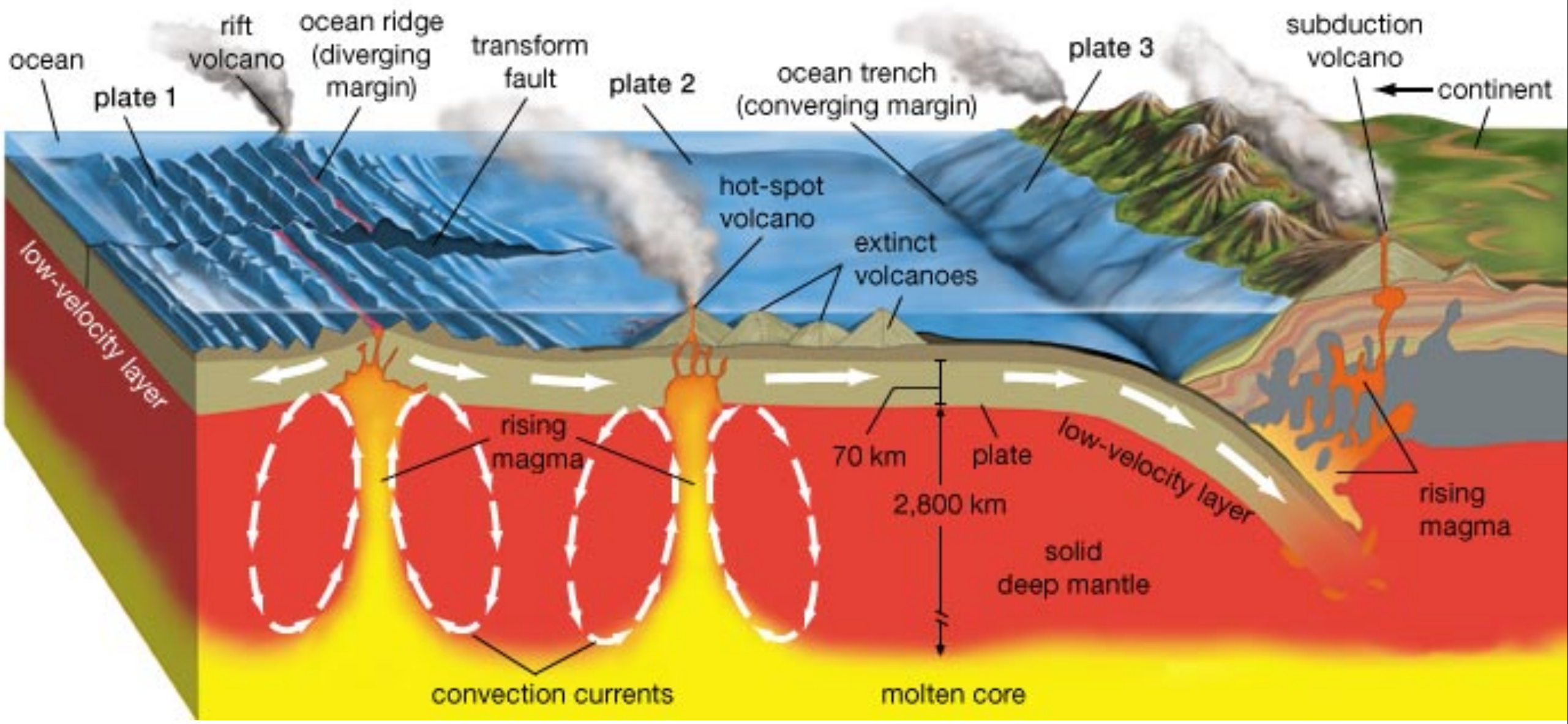


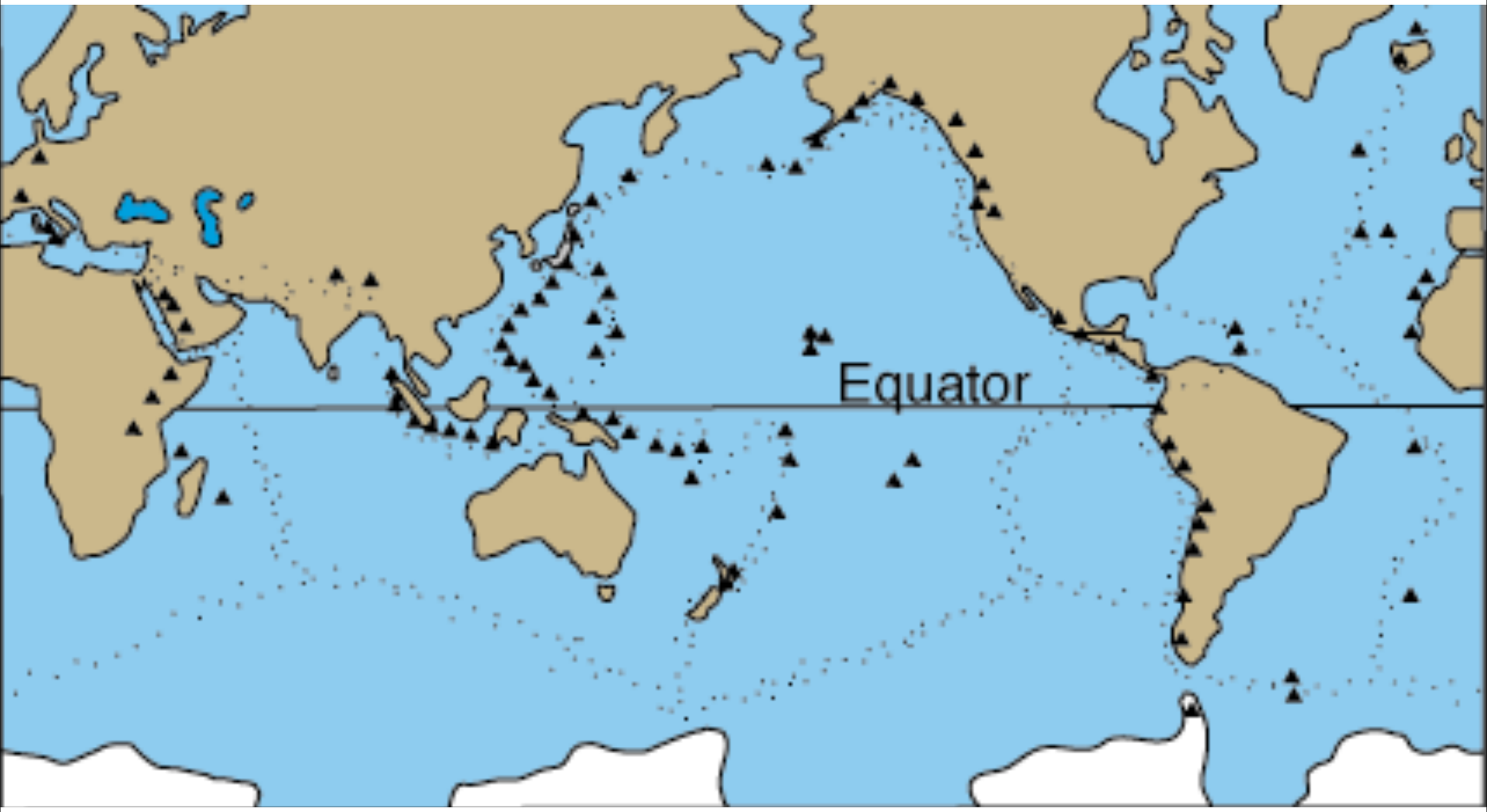
The Earth's outer layer is called the lithosphere. It is made of the rigid upper mantle and the crust. The lithosphere moves on the asthenosphere, part of the mantle that flows.

How do we know where the <u>edges</u> of the Plates are?

VOLCANOES AND EARTHQUAKES

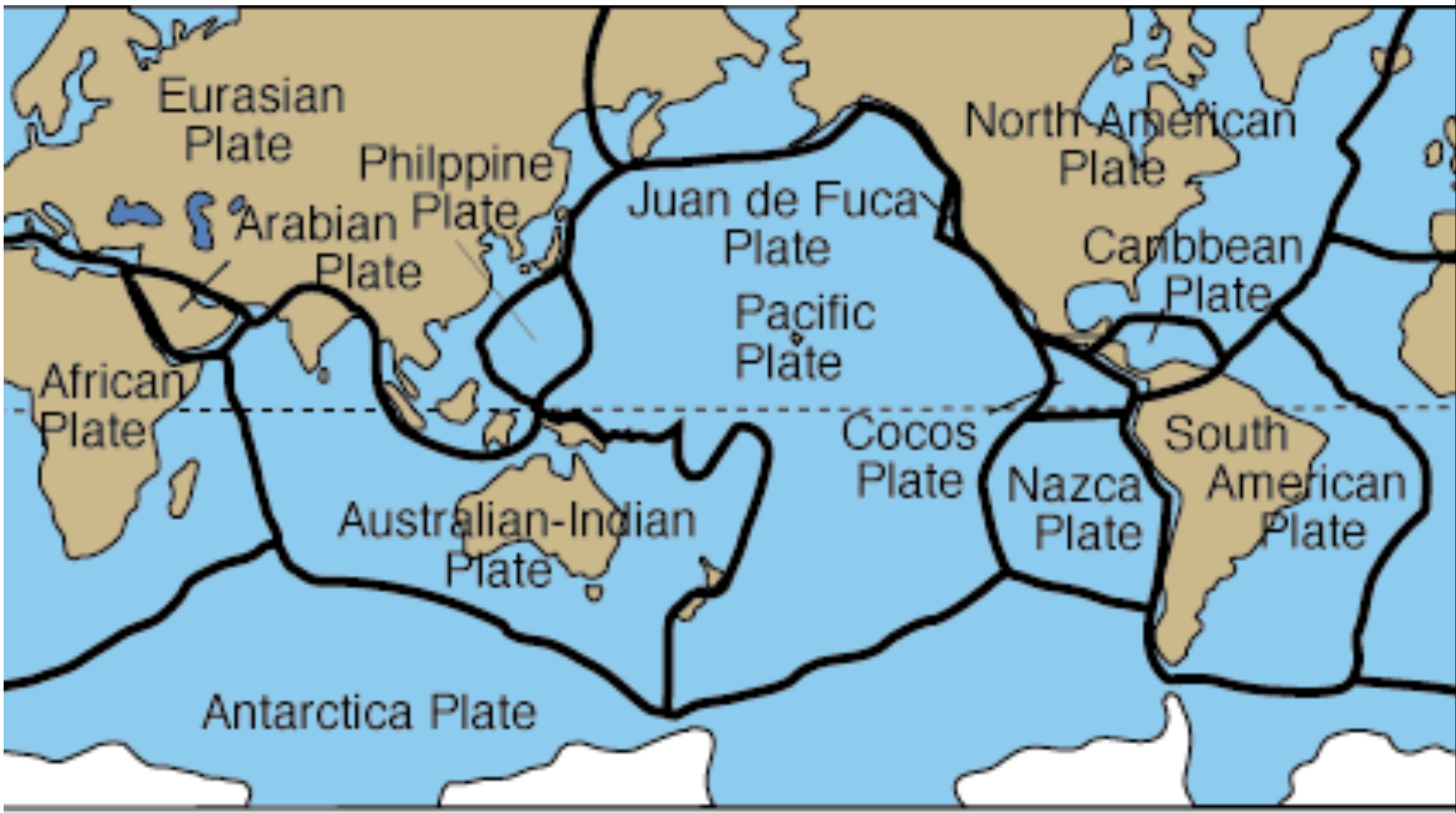
- The location of **volcanoes** and **earthquakes** often indicate the <u>edges</u> of the plates:





triangles = volcanoes

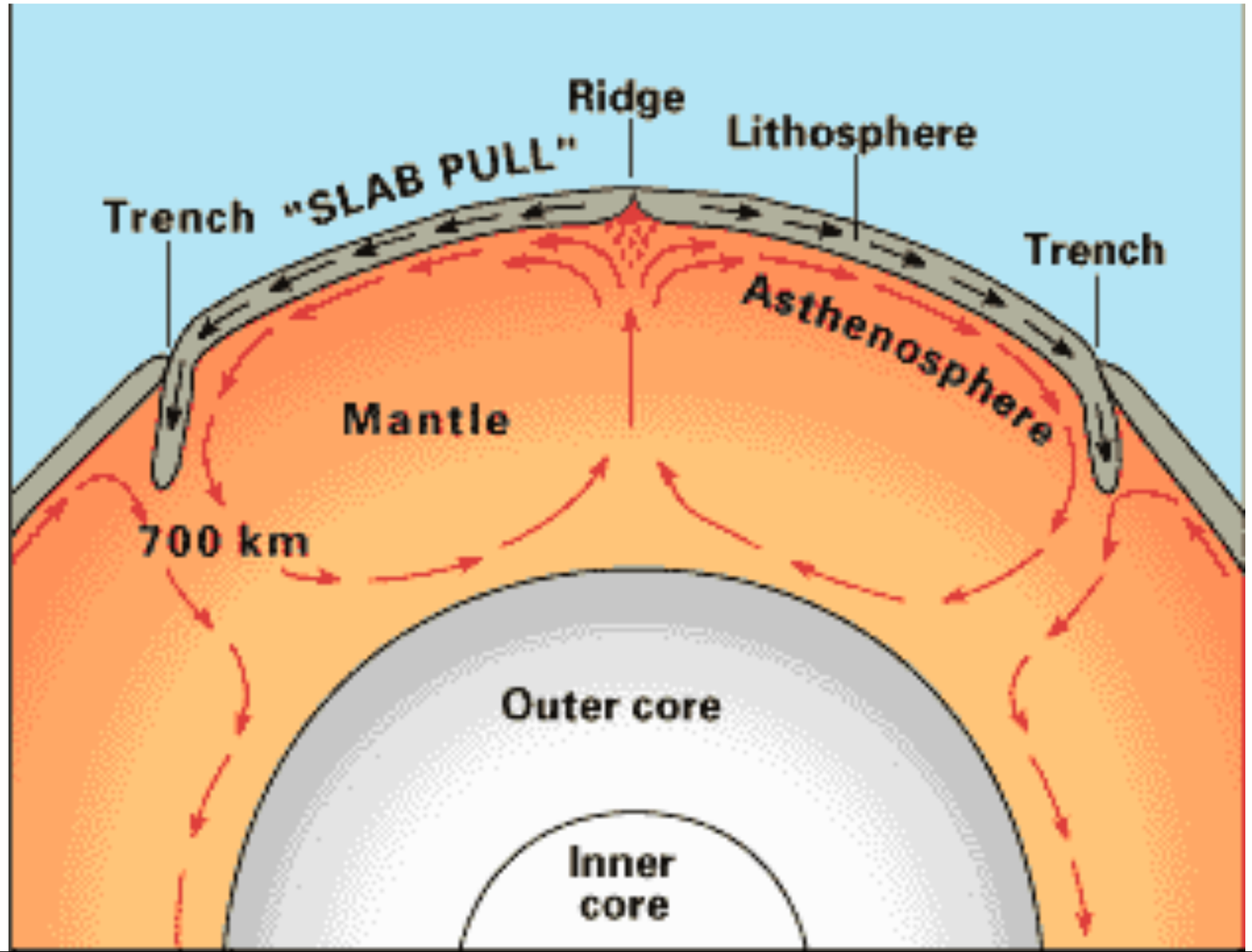
dots = earthquakes



Major tectonic plates of the world.

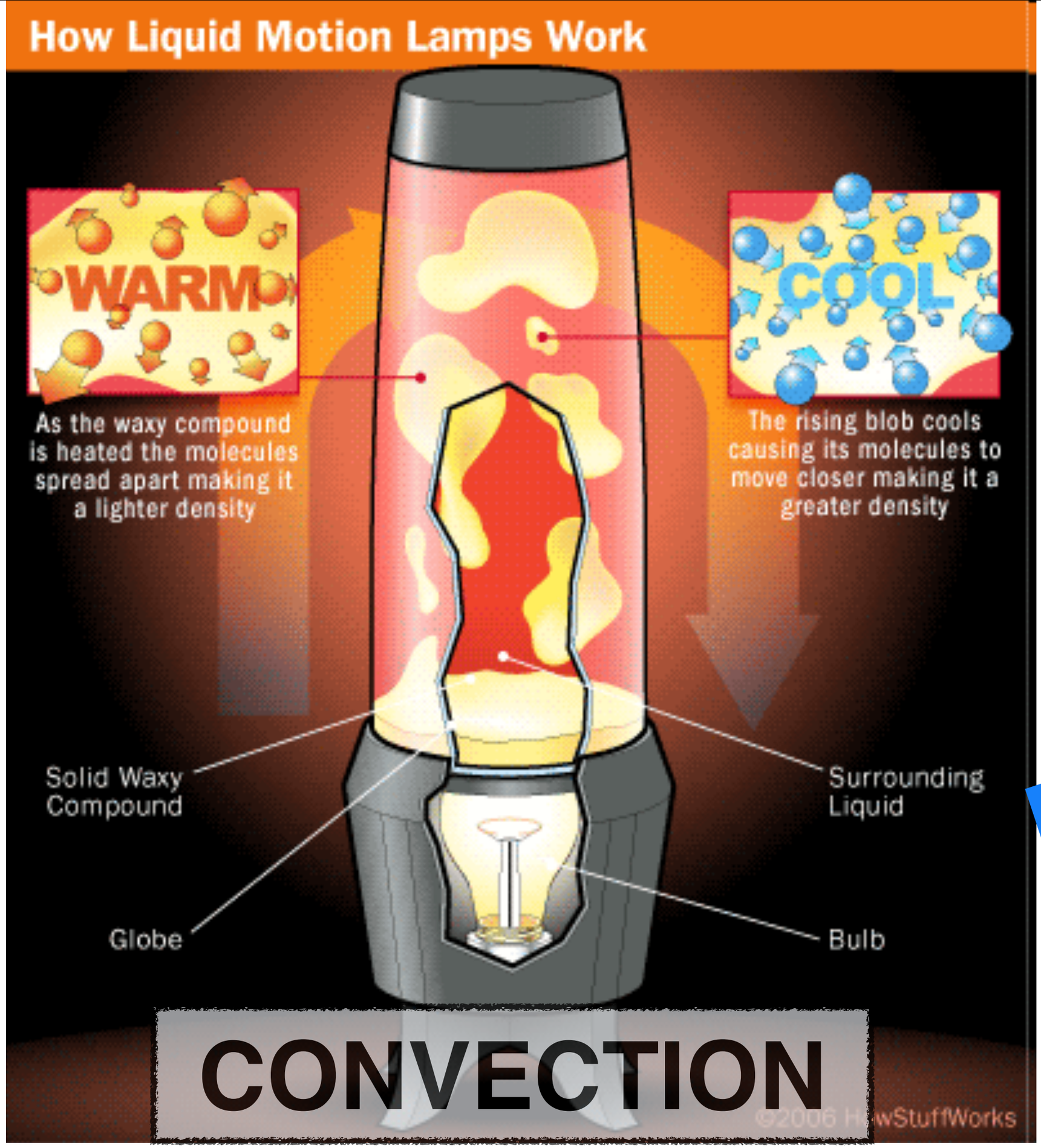
How do the Plates MOVE?

- Mantle **convection** within the asthenosphere.
- The theory of Plate Tectonics states that the plates move due to **CONVECTION** of heated rock in the **liquid mantle**!



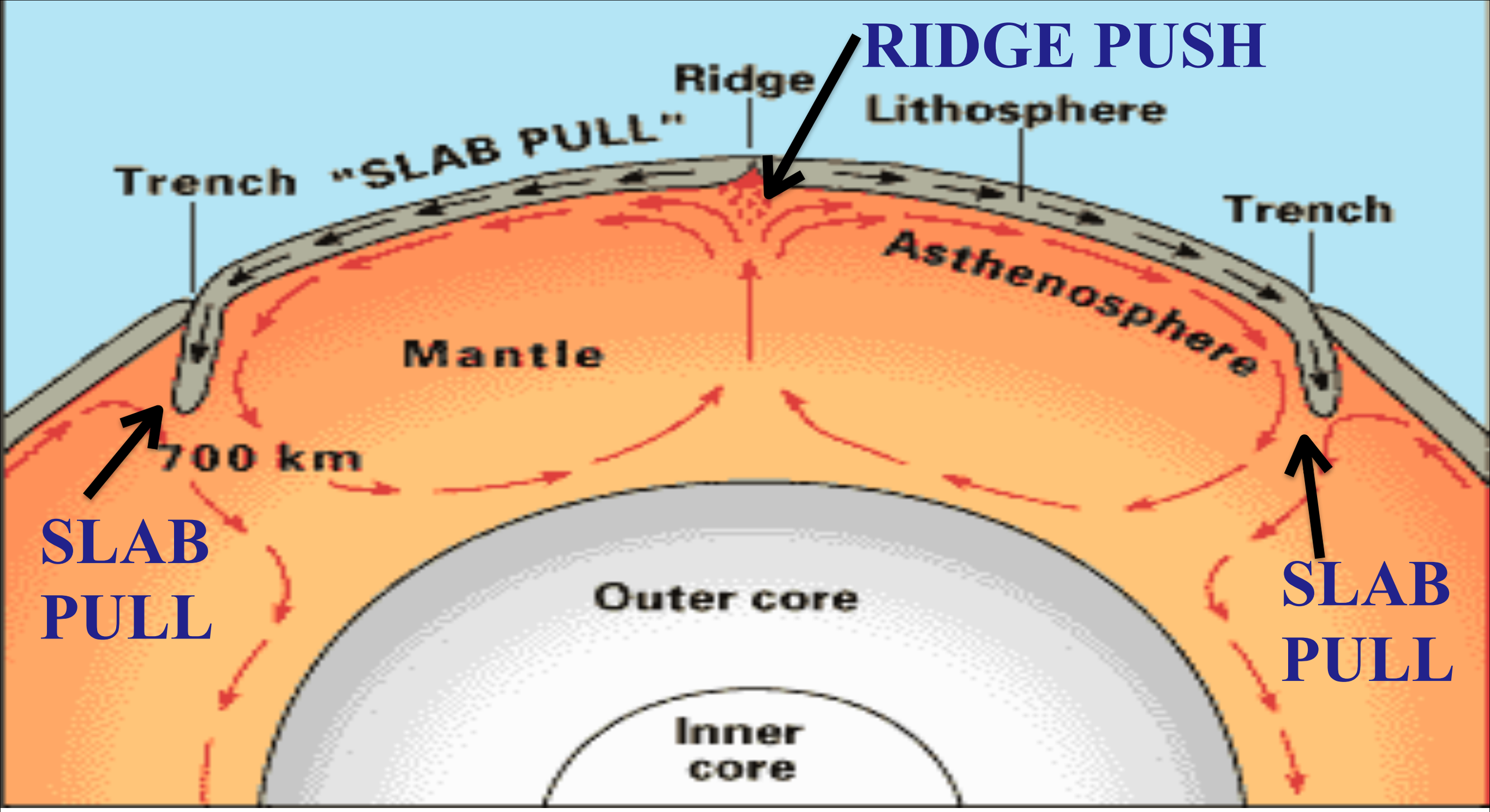
But what is 'Convection?'

Hot fluid rises
(it is less dense!)

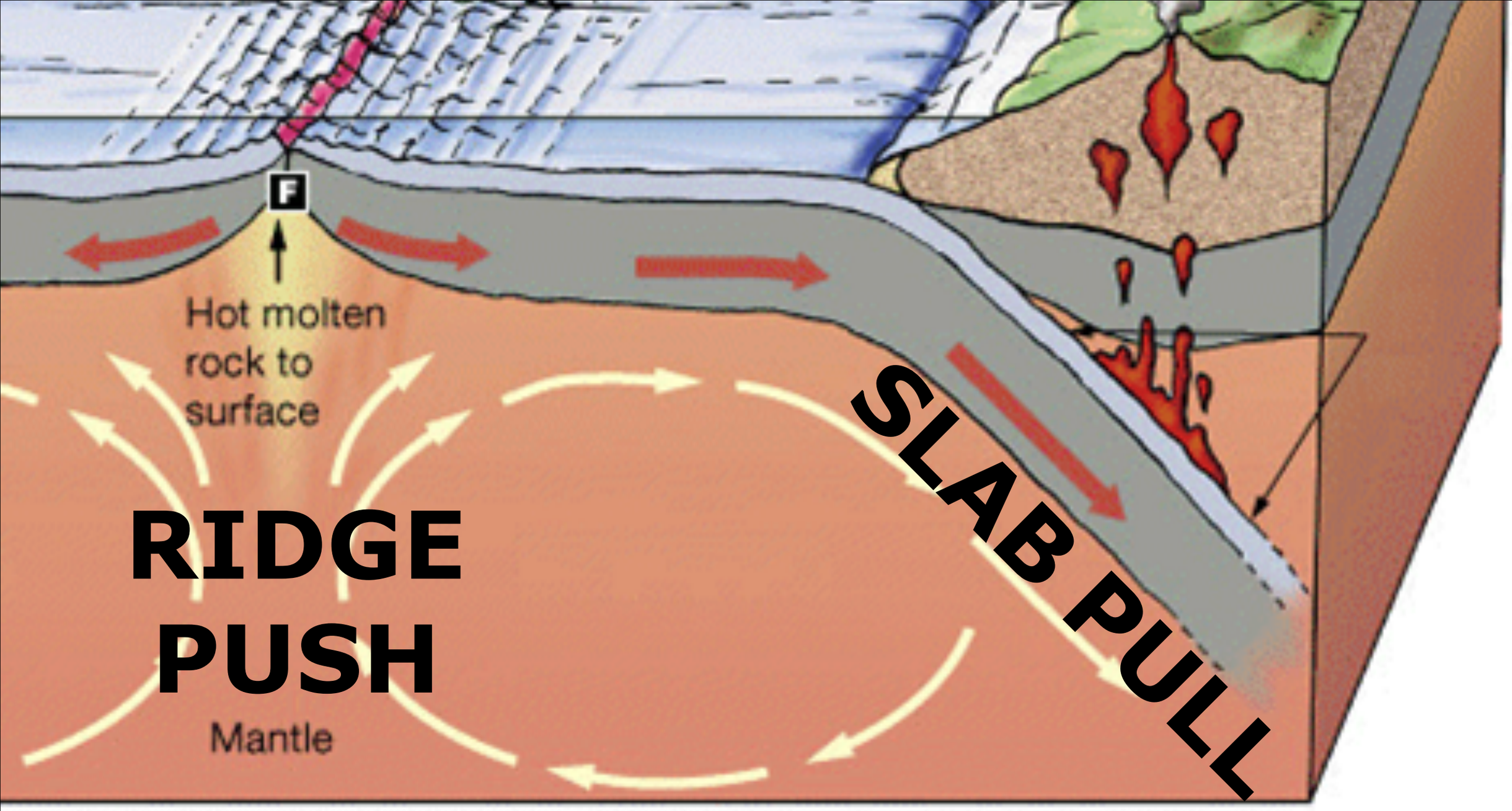


Cold fluid sinks
(it is more dense!)

CONVECTION



- Convection currents in the mantle "**ridge push**" and "**slab pull**" the crustal plates.
- <u>New crust</u> is created where plates move apart!

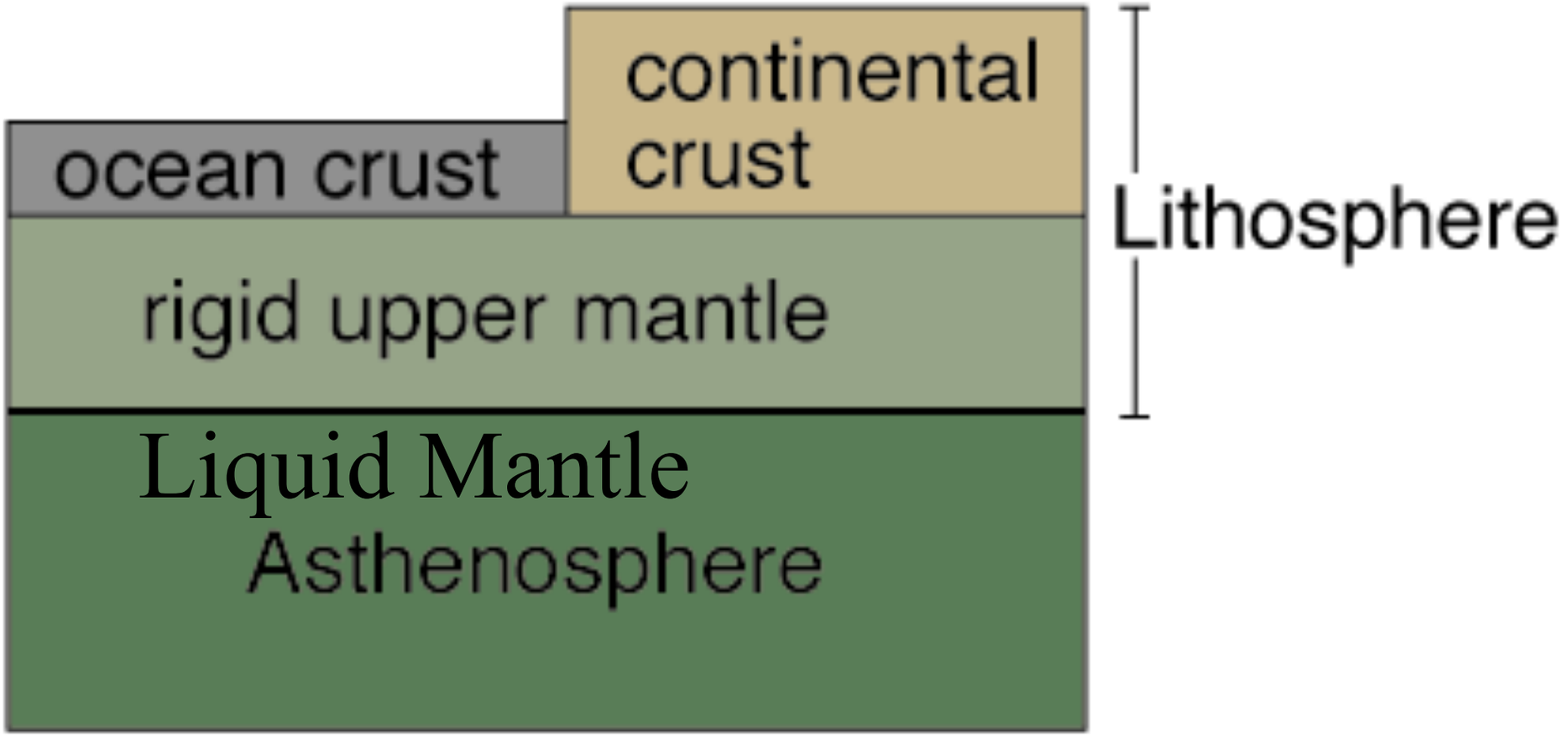


Magma upwelling and pushing plates apart at mid-ocean ridges.

Plate pulled down by gravity at trenches in subduction zones.

PLATE TECTONICS #3

Plate Boundaries



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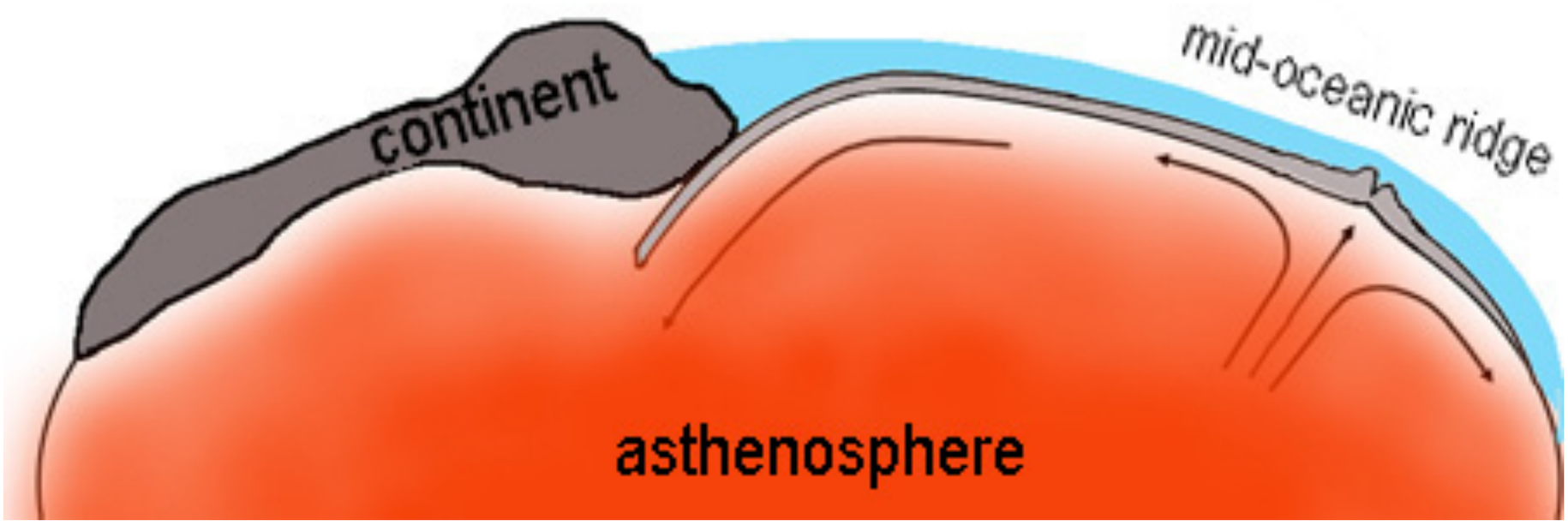
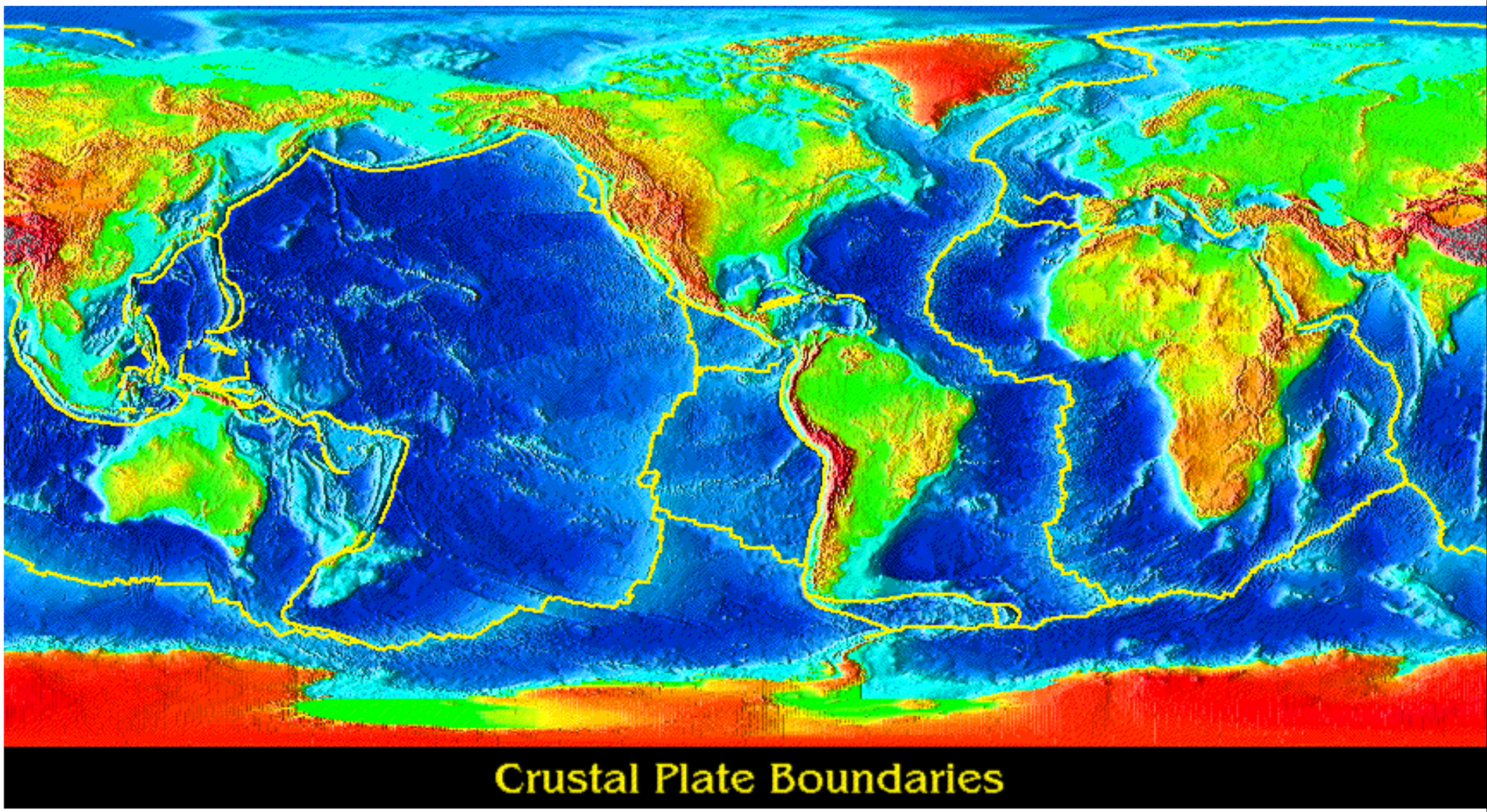


What happens at **Plate Boundaries**?



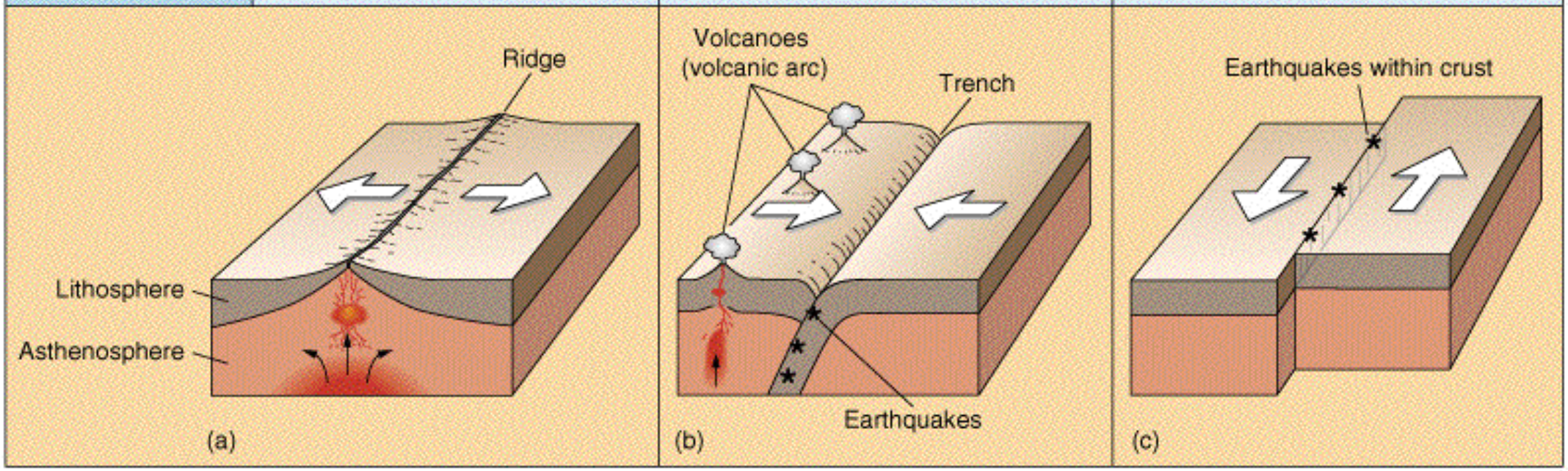
Which way are each plate **moving**?

What **features** does this movement cause?

PLATE BOUNDARIES

- There are three types of boundaries between tectonic plates:
  1. **DIVERGENT plate boundary**
  2. **CONVERGENT plate boundary**
  3. **TRANSFORM plate boundary**

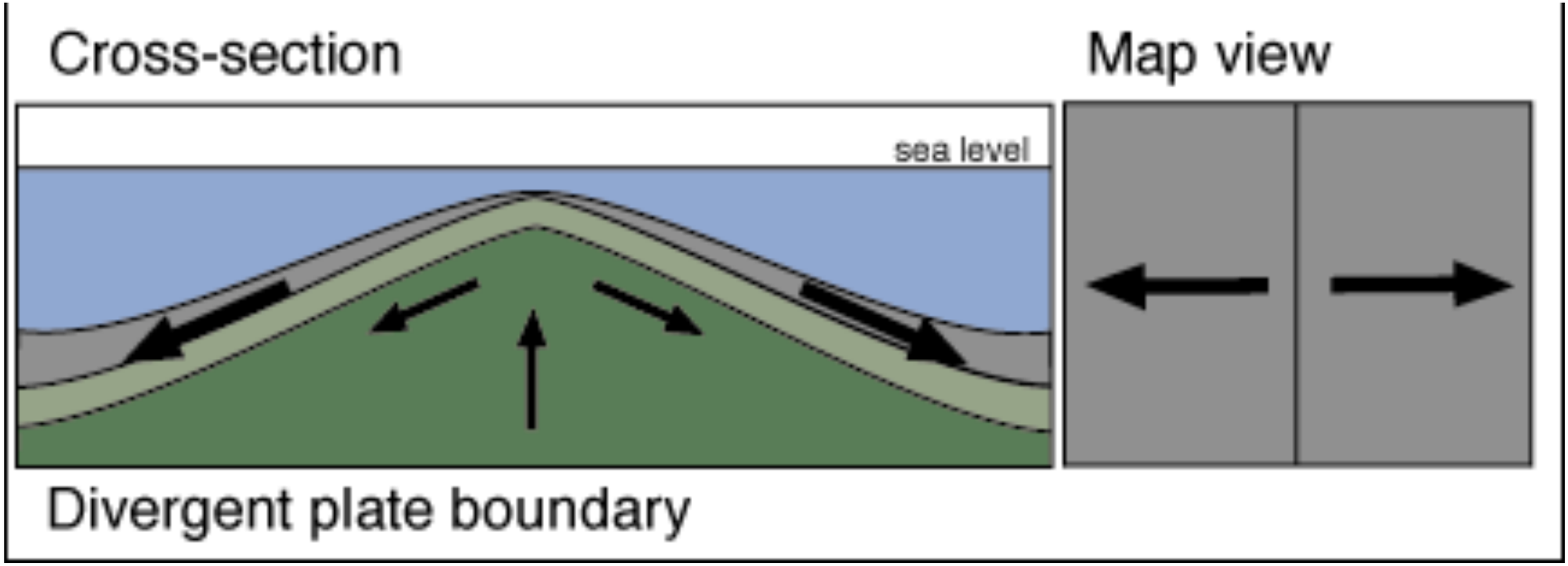
Type of Margin	Divergent	Convergent	Transform
Motion	Spreading	Subduction	Lateral sliding
Effect	Constructive (oceanic lithosphere created)	Destructive (oceanic lithosphere destroyed)	Conservative (lithosphere neither created or destroyed)
Topography	Ridge/Rift	Trench	No major effect
Volcanic activity?	Yes	Yes	No



DIVERGENT
Plate Boundary

1. <u>DIVERGENT</u> plate boundary

- The plates move **APART** from each other.
- As the plates separate, fresh new magma rises and cools, creating NEW oceanic crust!

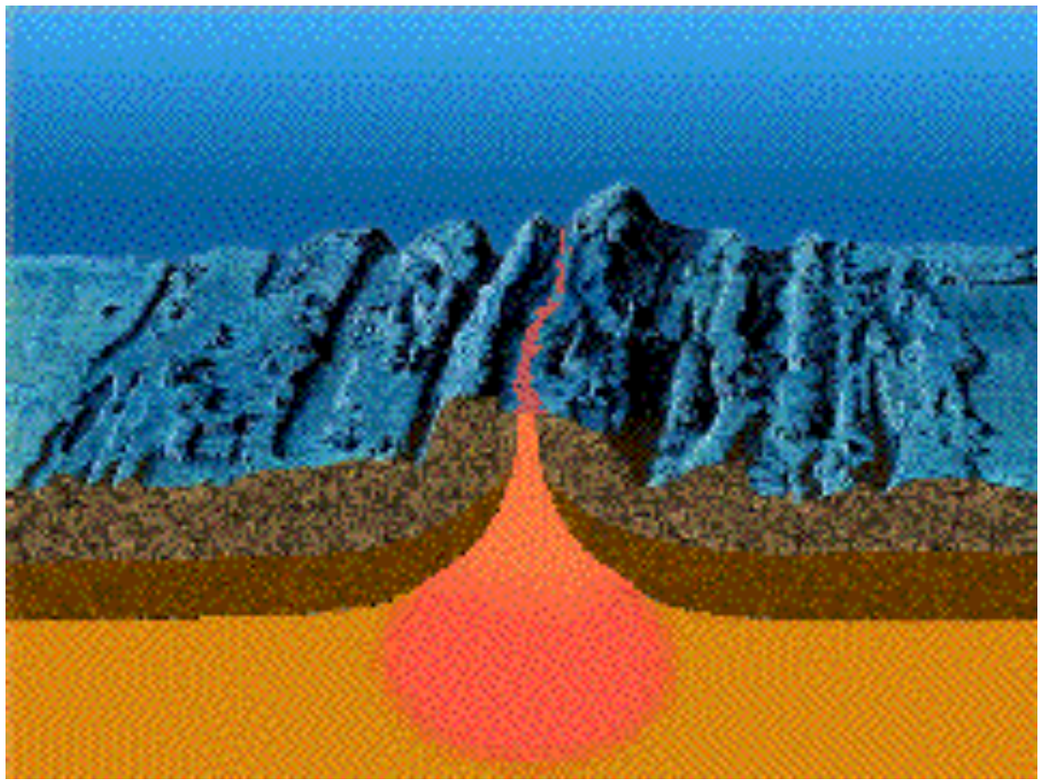


DIVERGENT plate boundary

- If under ***oceanic*** **crust**

= **Sea-Floor Spreading and Ocean Ridges.**

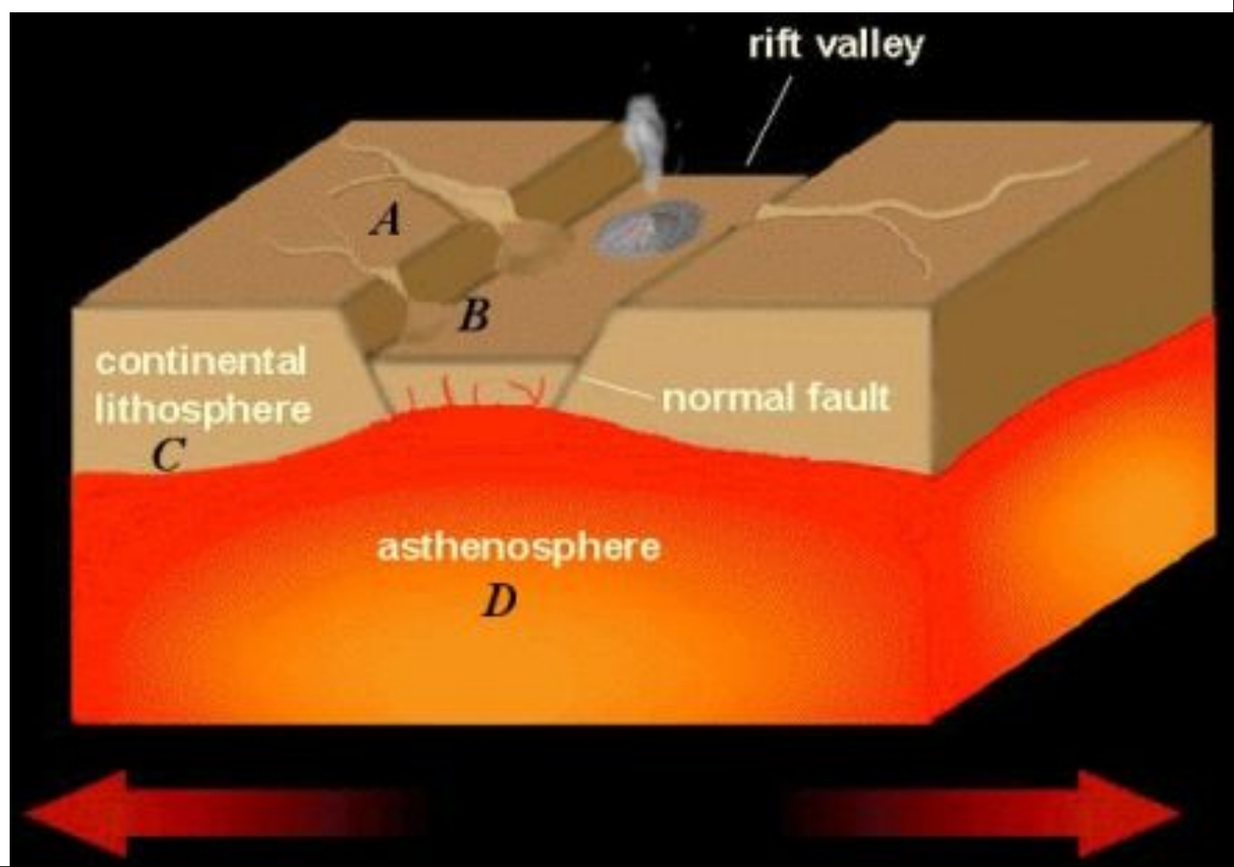
  - » Eg. Mid-Atlantic Ridge and Iceland!
  - » Hydrothermal vents occur.



- If under ***continental*** **crust**

= **Rift Valley.**

  - » Eg. Africa's Great Rift Valley!




EUROPE
SAHARA
DESERT
CONGO
BASIN
KALAHARI
DESERT

RIFT VALLEY

MID-OCEAN RIDGE

CONVERGENT
Plate Boundary

2. <u>CONVERGENT</u> plate boundary

- The plates move **TOGETHER**.
- There are <u>three</u> types of converging plate boundary:

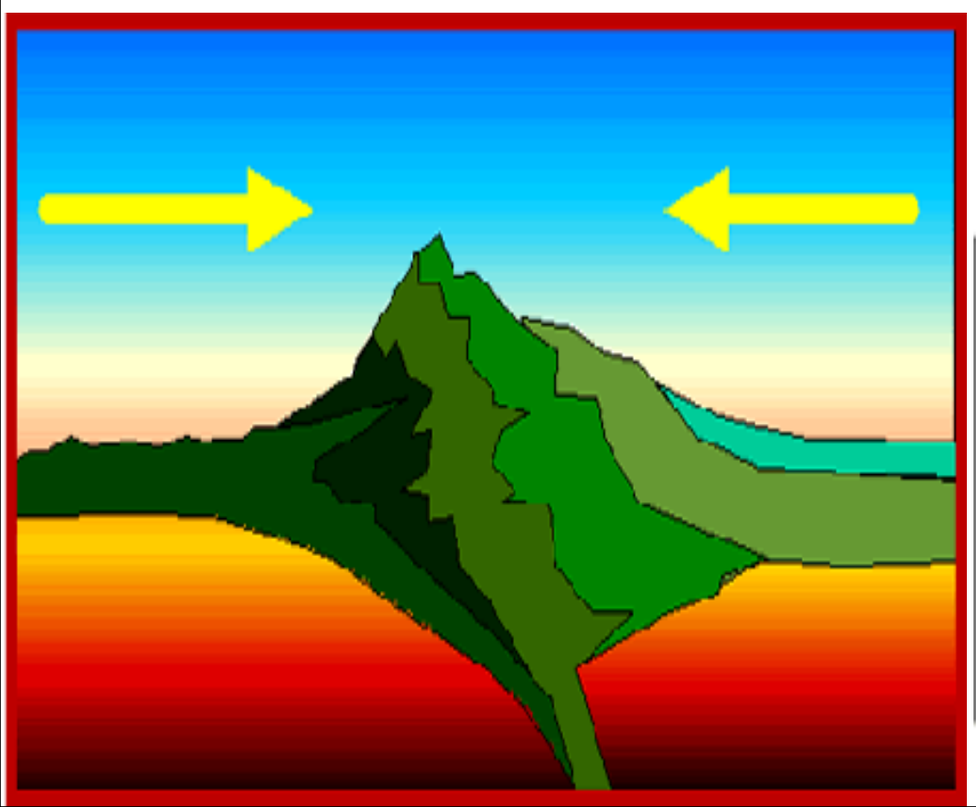
a. Continental crust – Continental crust. ***(C - C)***

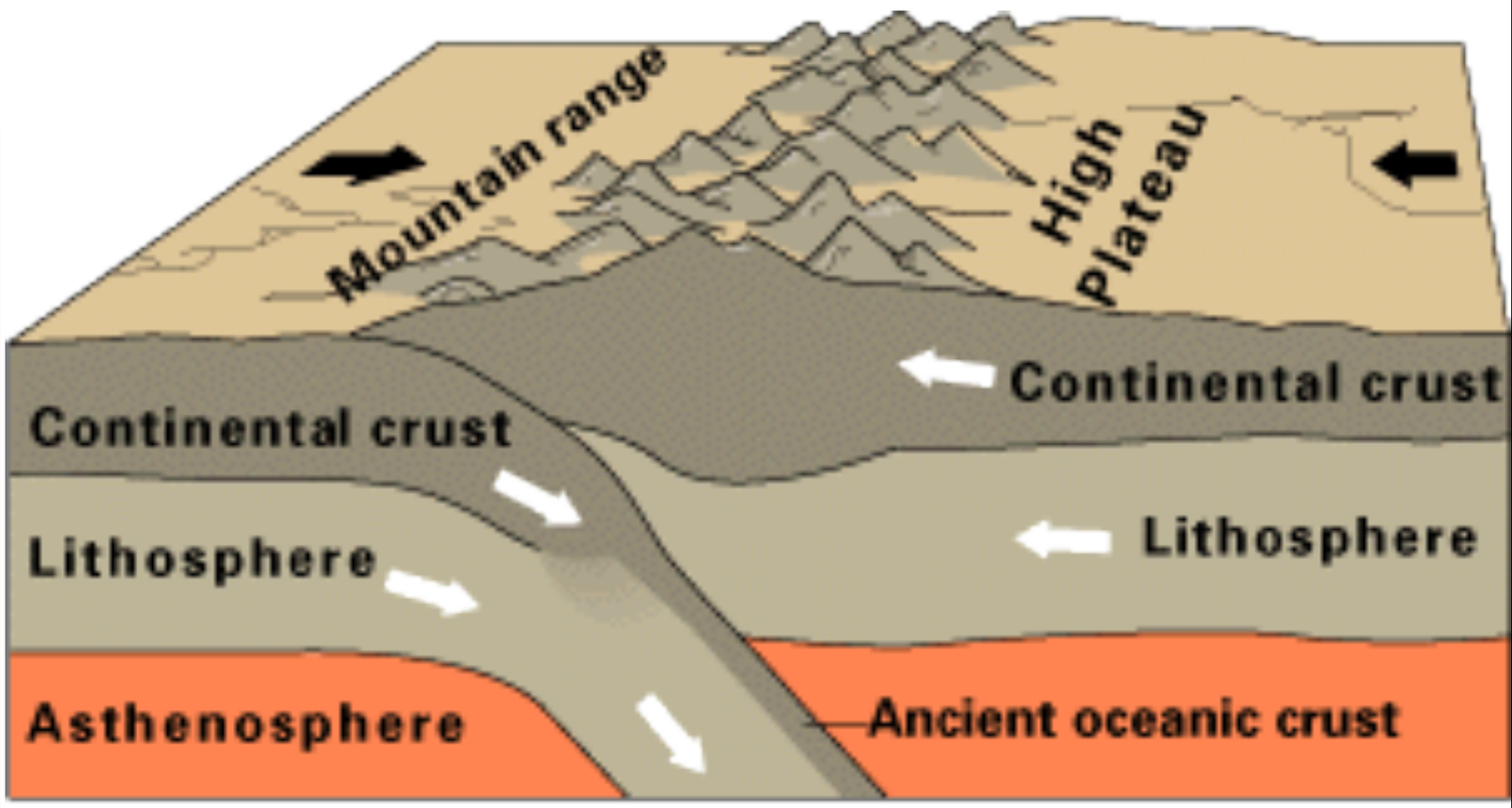
b. Continental crust – Oceanic crust ***(C - O)***

c. Oceanic crust – Oceanic crust ***(O - O)***

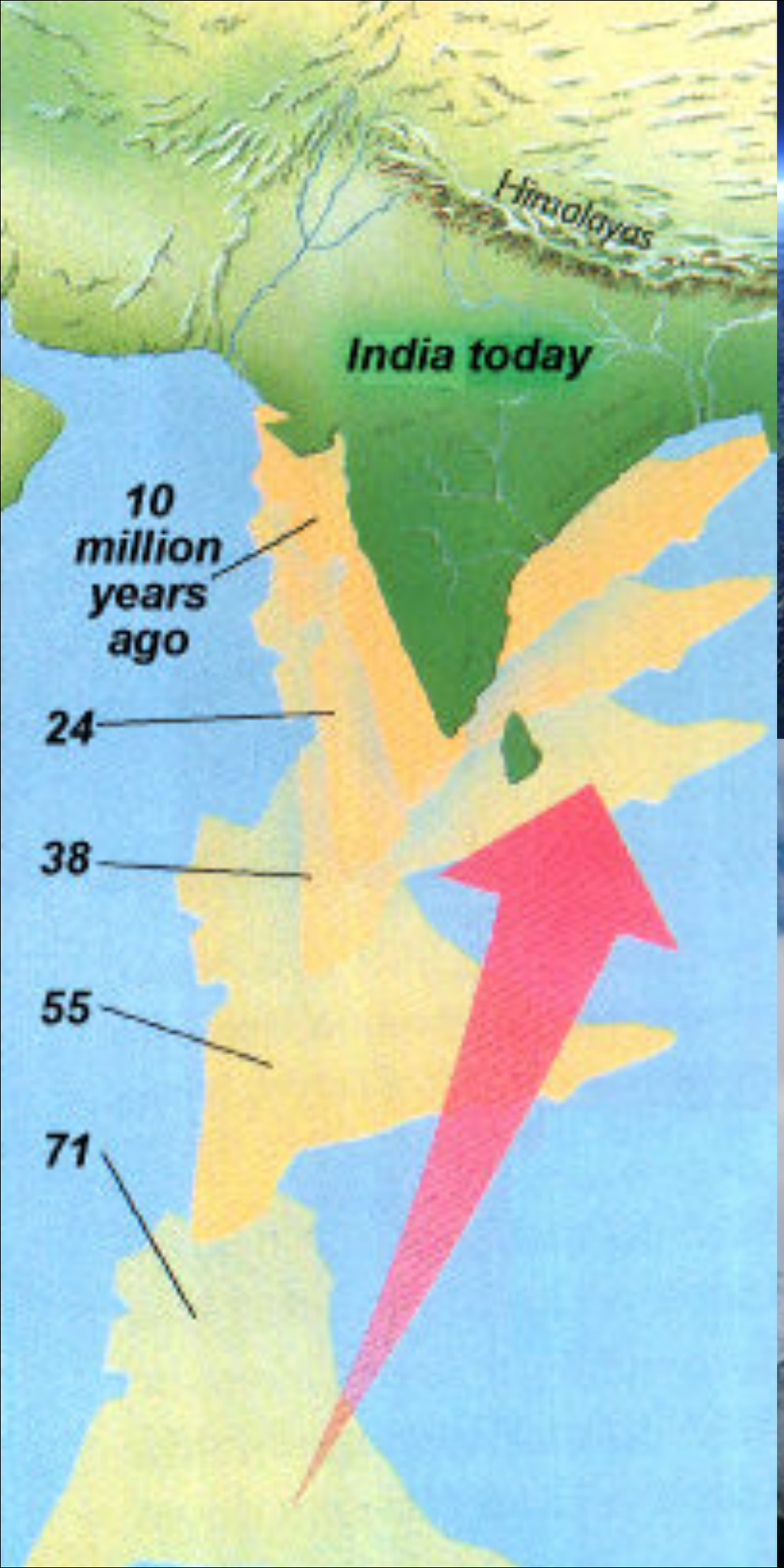
CONVERGENT plate boundary
a. Continental - Continental

- Creates <u>MOUNTAINS</u>!
- Causes lots of <u>Earthquakes</u>.
  - Eg. The India Plate is pushing northward into China at about 5cm/year. The Himalayan Mountains (and Mount Everest) are the result!



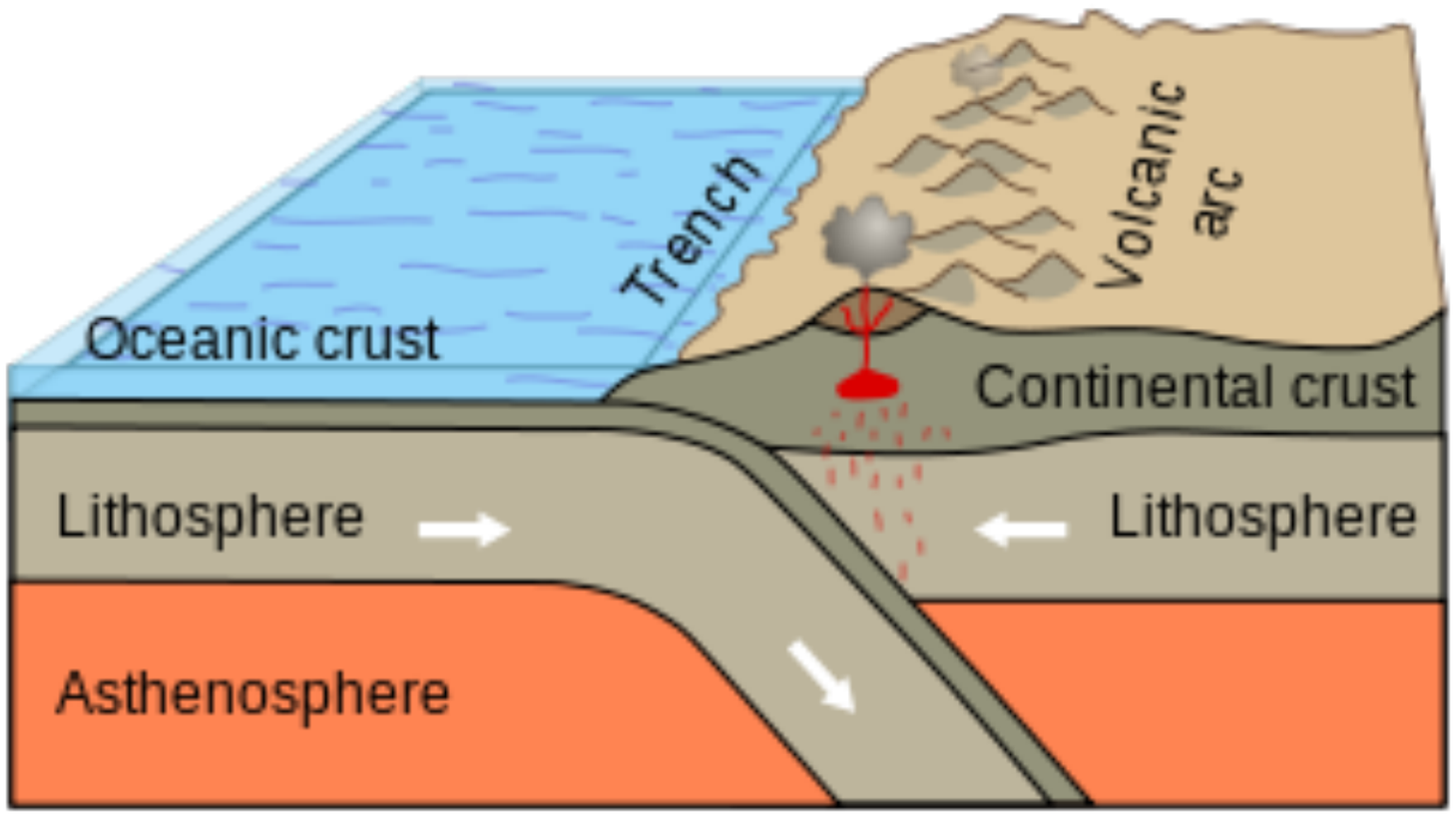


Continental-continental convergence

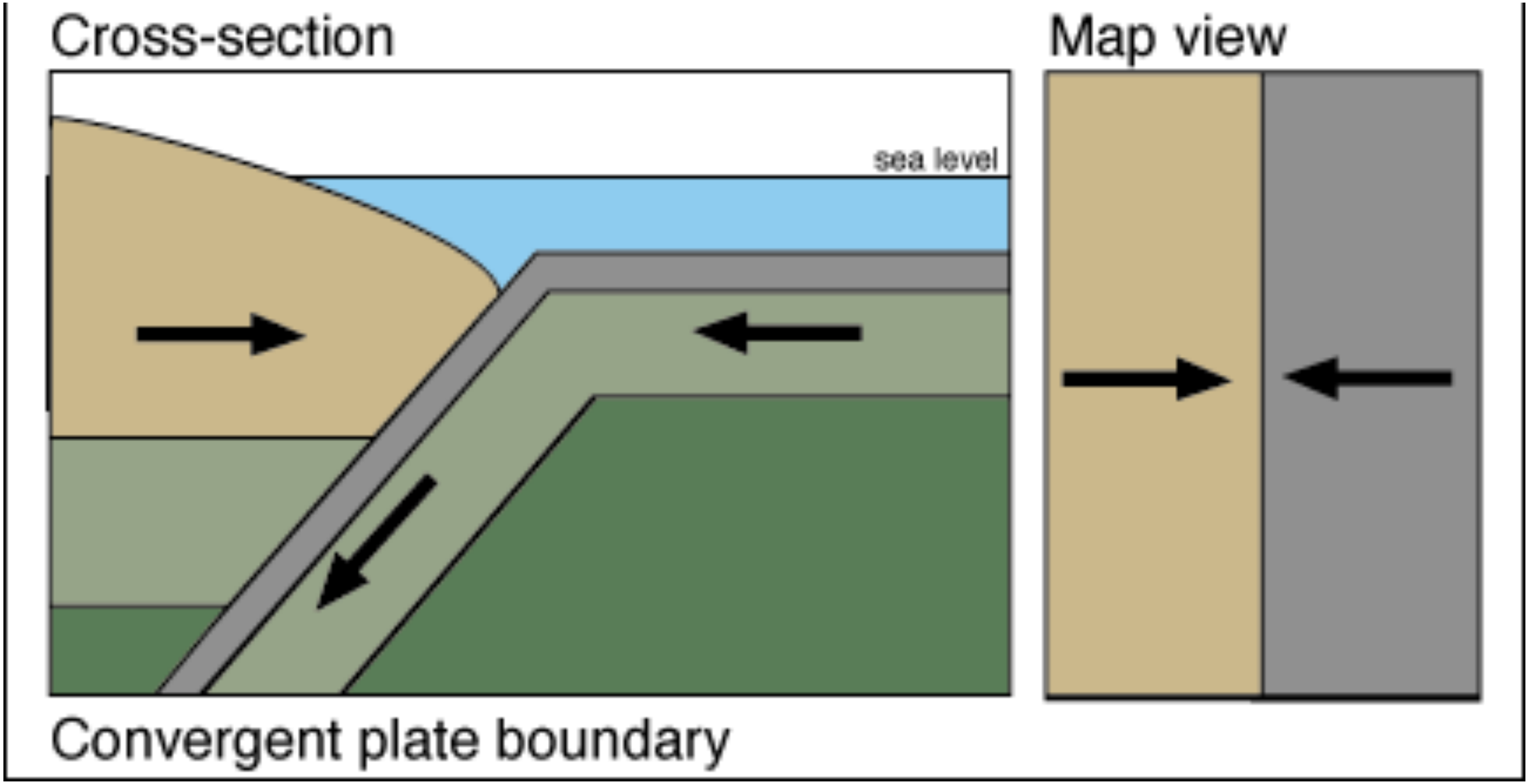

Himalayas
India today
10 million years ago
24
38
55
71

CONVERGENT plate boundary
b. Continental - Oceanic

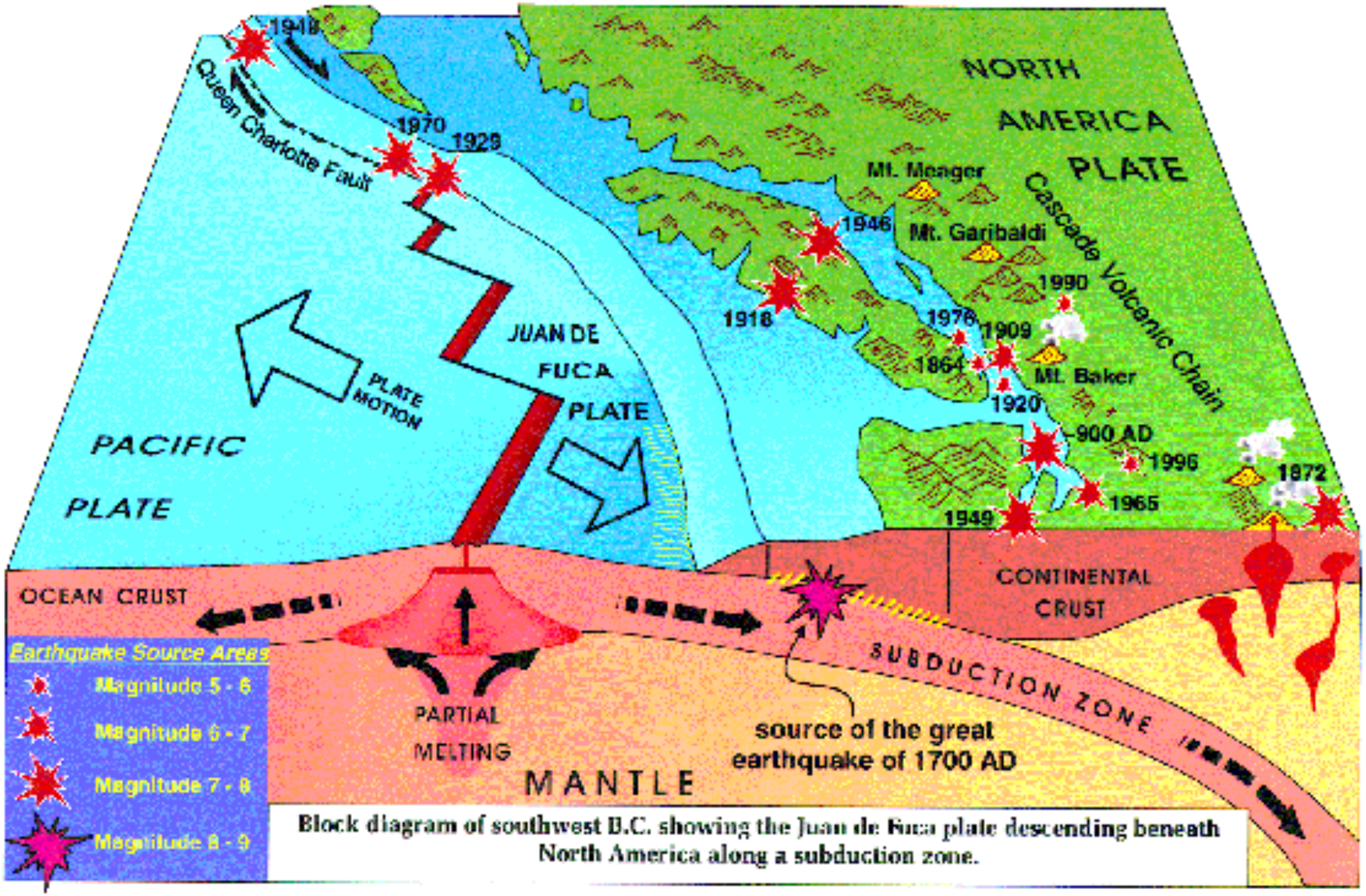
- Creates a **<u>Subduction Zone</u>** = the denser Oceanic Plate slides under the less-dense Continental Plate, creating a deep-sea **trench**.
- Causes lots of **<u>Earthquakes</u>**, some very deep.
- Causes lots of **<u>Volcanoes</u>**!



Subduction Zone



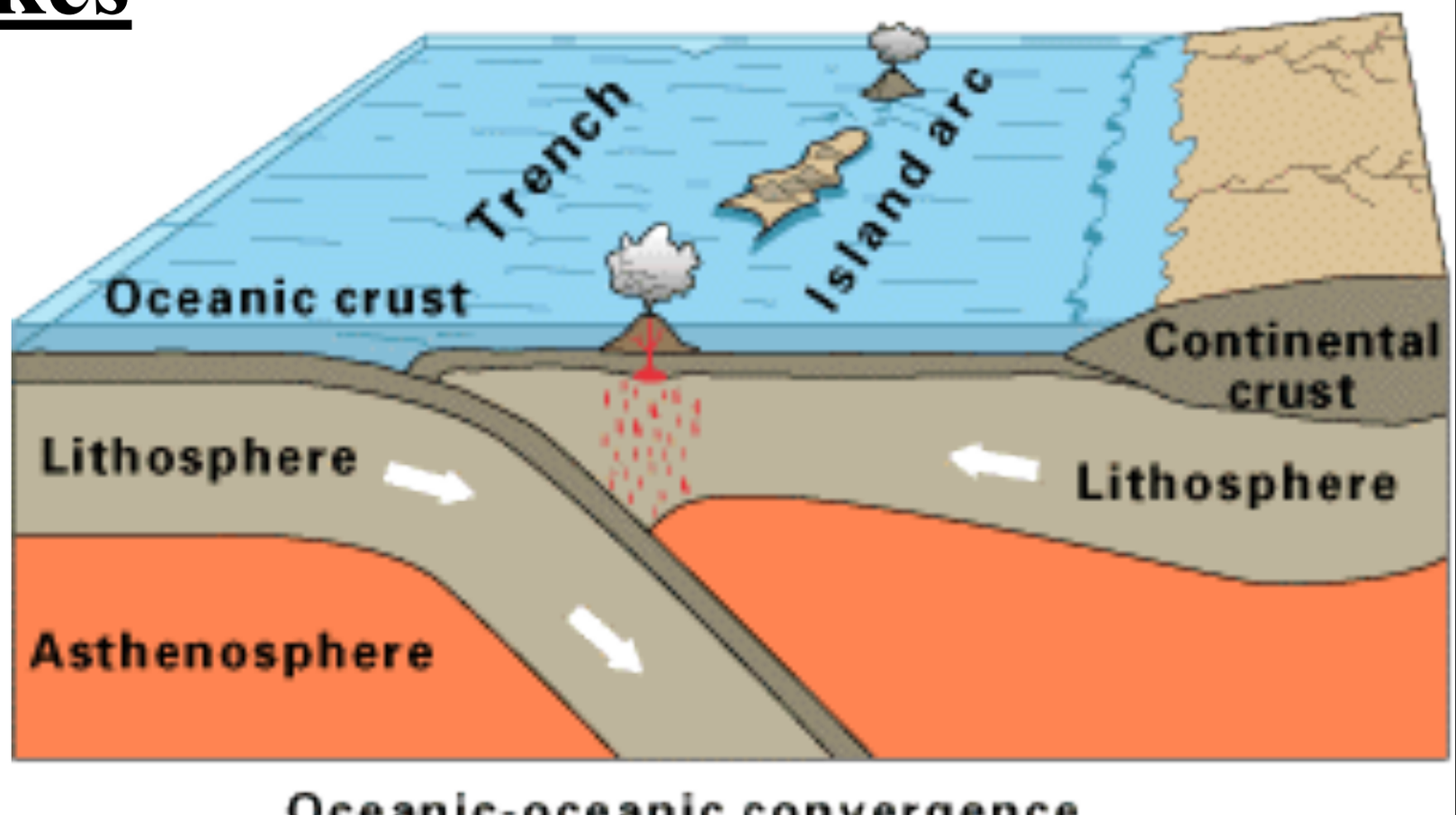
- Eg. The **Juan de Fuca Plate** is subducting below the North American Plate. The oceanic plate melts as it sinks; creating magma that moves up and erupts, making volcanoes such as Mount St. Helens.



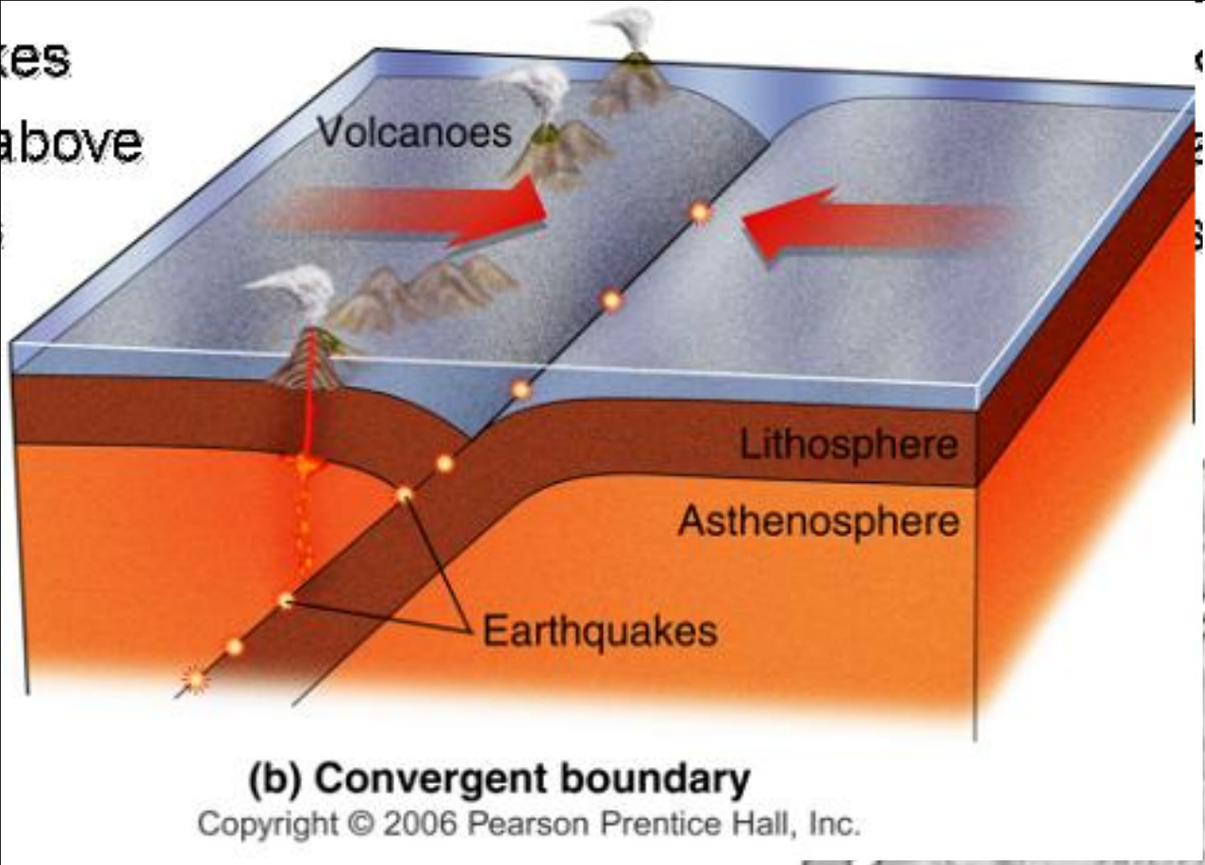
Block diagram of southwest B.C. showing the Juan de Fuca plate descending beneath North America along a subduction zone.

CONVERGENT plate boundary
c. **Oceanic - Oceanic**

- Creates a **<u>Volcanic Island Arc</u>** = one of the oceanic plates subducts under the other, melts, and the magma rises to create a chain of volcanoes, and a parallel deep-sea **trench**.
- Causes **<u>Earthquakes</u>**
- Causes chains of **<u>volcanic</u>** islands.

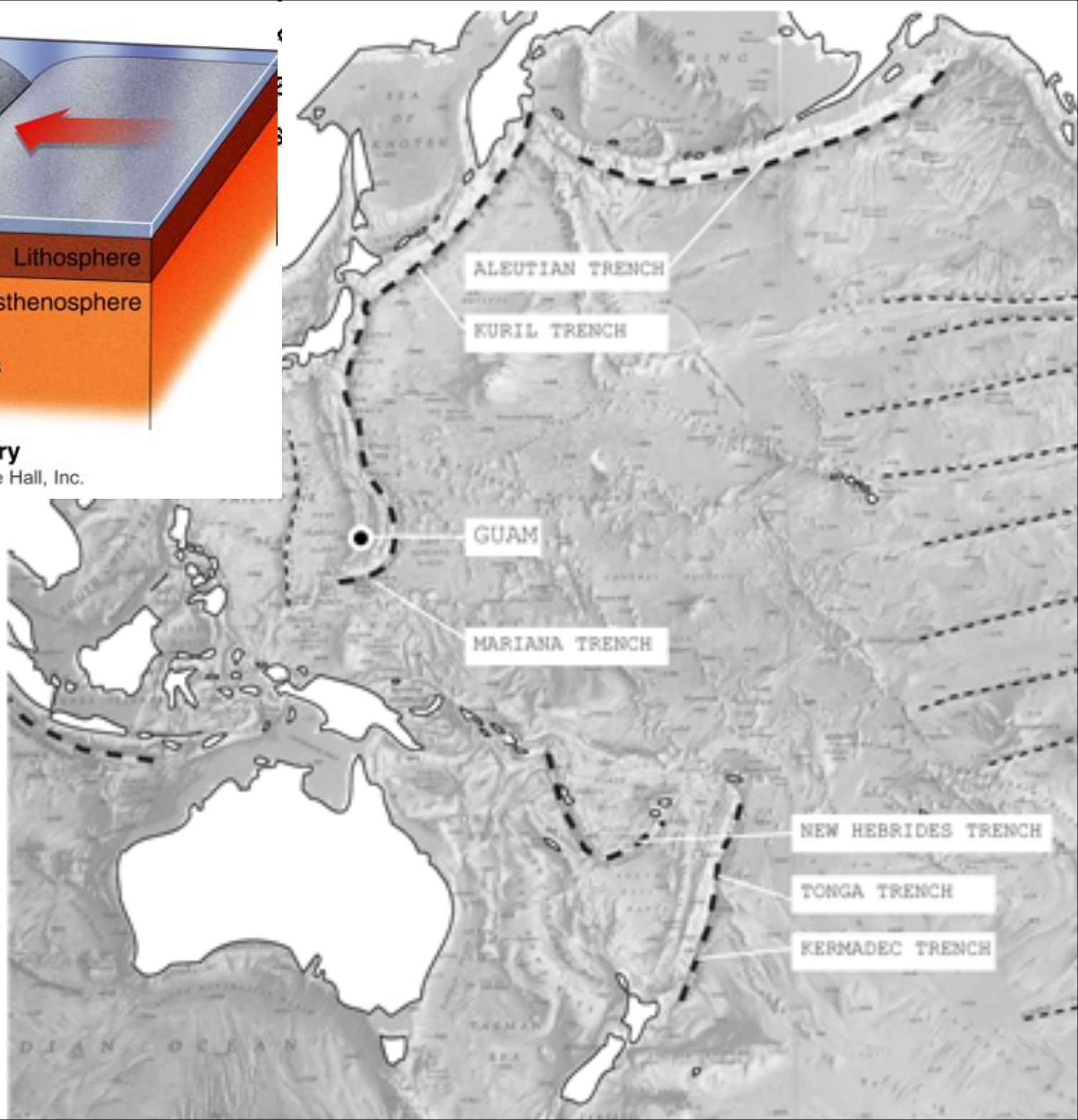


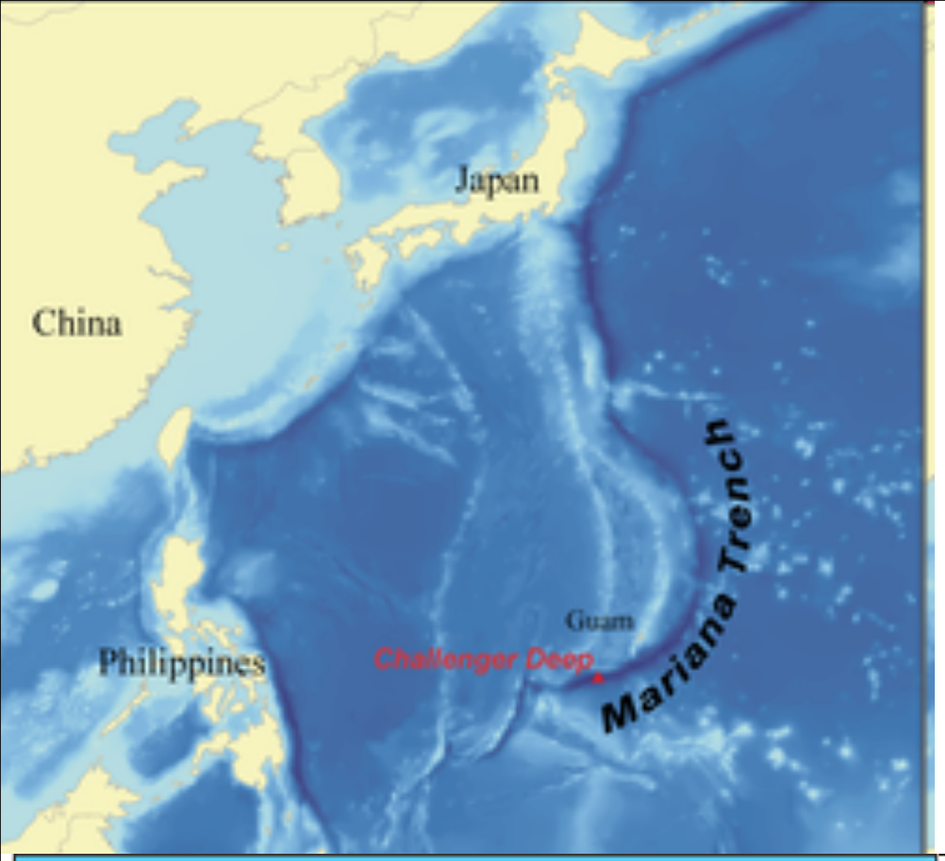
Oceanic-oceanic convergence

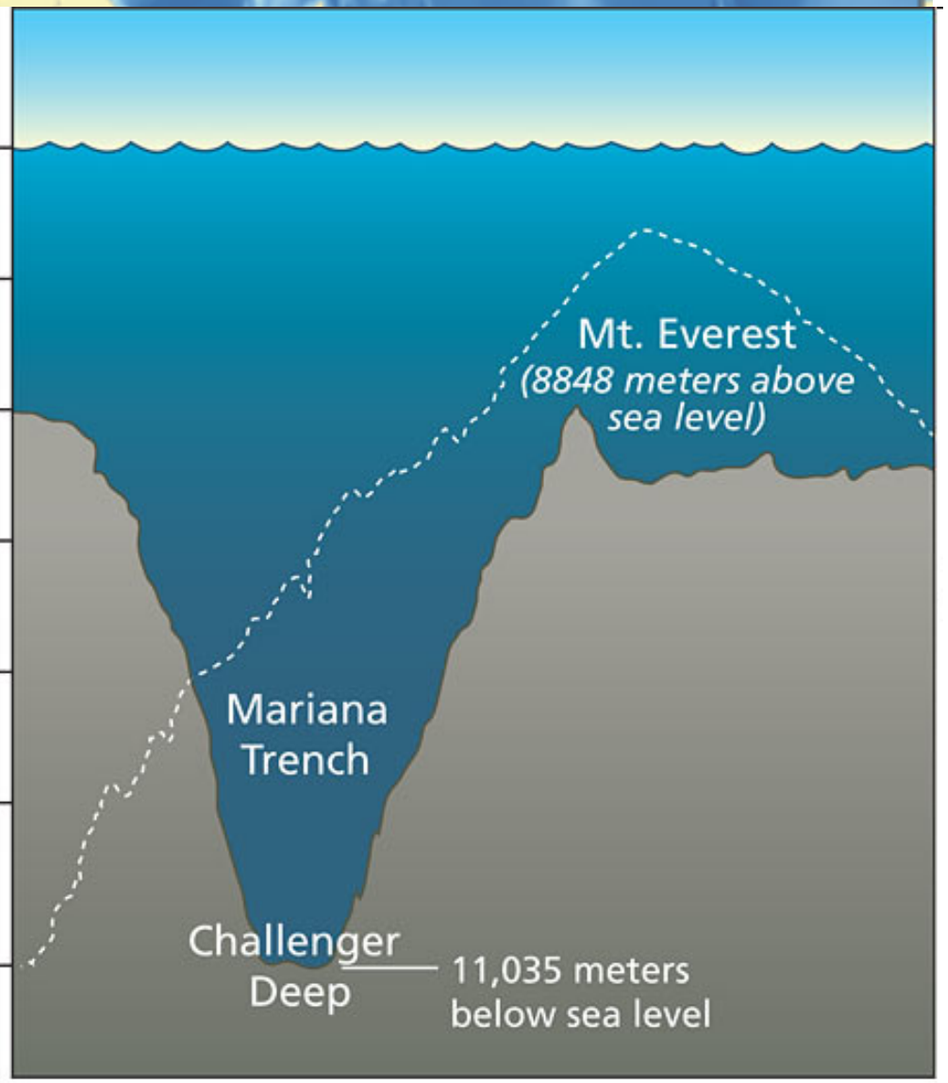


(b) Convergent boundary

Creating a Volcanic **Island Arc**, and **Trench**.







- Eg. The *Philippine Plate* is subducting under the *Pacific Plate*, creating the **Mariana Trench** (the deepest trench in the oceans! –11,035 m)

- The Mariana Islands (and Guam) run parallel to the trench.

- In March 2012, James Cameron explored to the very bottom of the trench.

THE DEEPSEA CHALLENGER

FACTFILE

- Height: 24ft
- Weight: 12 tons
- Made from a specialised glass foam
- It took two hours and 36 minutes to reach a depth of 35,736 feet, a rate of 500 feet per minute. He rose to the surface in 70 minutes

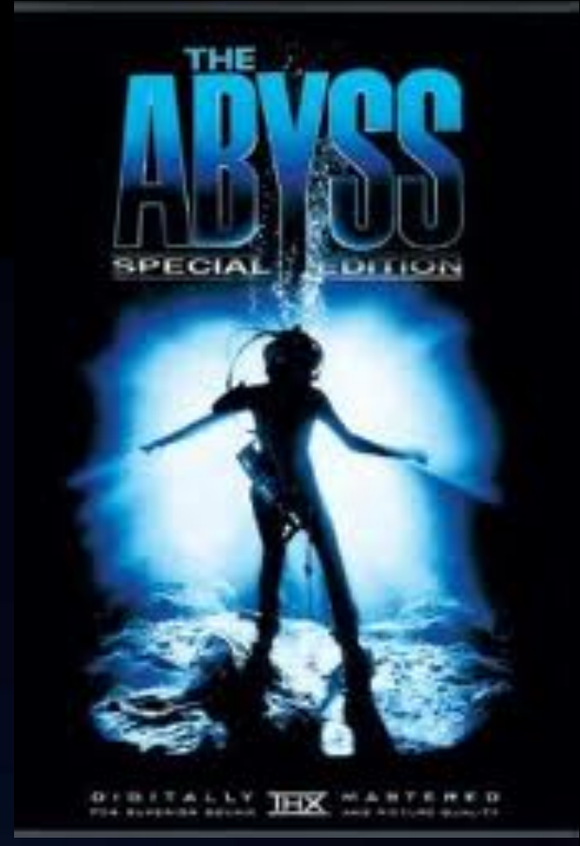
SUCCESS: James Cameron on his return to the surface

- DEEPEST SCUBA DIVE: 1,044ft
- BLUE WHALE: 3,000ft
- DEEPEST MILITARY SUBMARINE: Soviet submarine K-278 Komsomolets, 4,265ft
- MOUNT EVEREST (29,029ft): If it was put into the Mariana trench it would still fall short of sea level by 7,000ft

Water pressure comparable to three Land Rovers resting on a toe - sub shrank by three inches under the pressure.

6,000ft
12,000ft
18,000ft
24,000ft
30,000ft
CHALLENGER DEEP 35,994ft
36,000ft

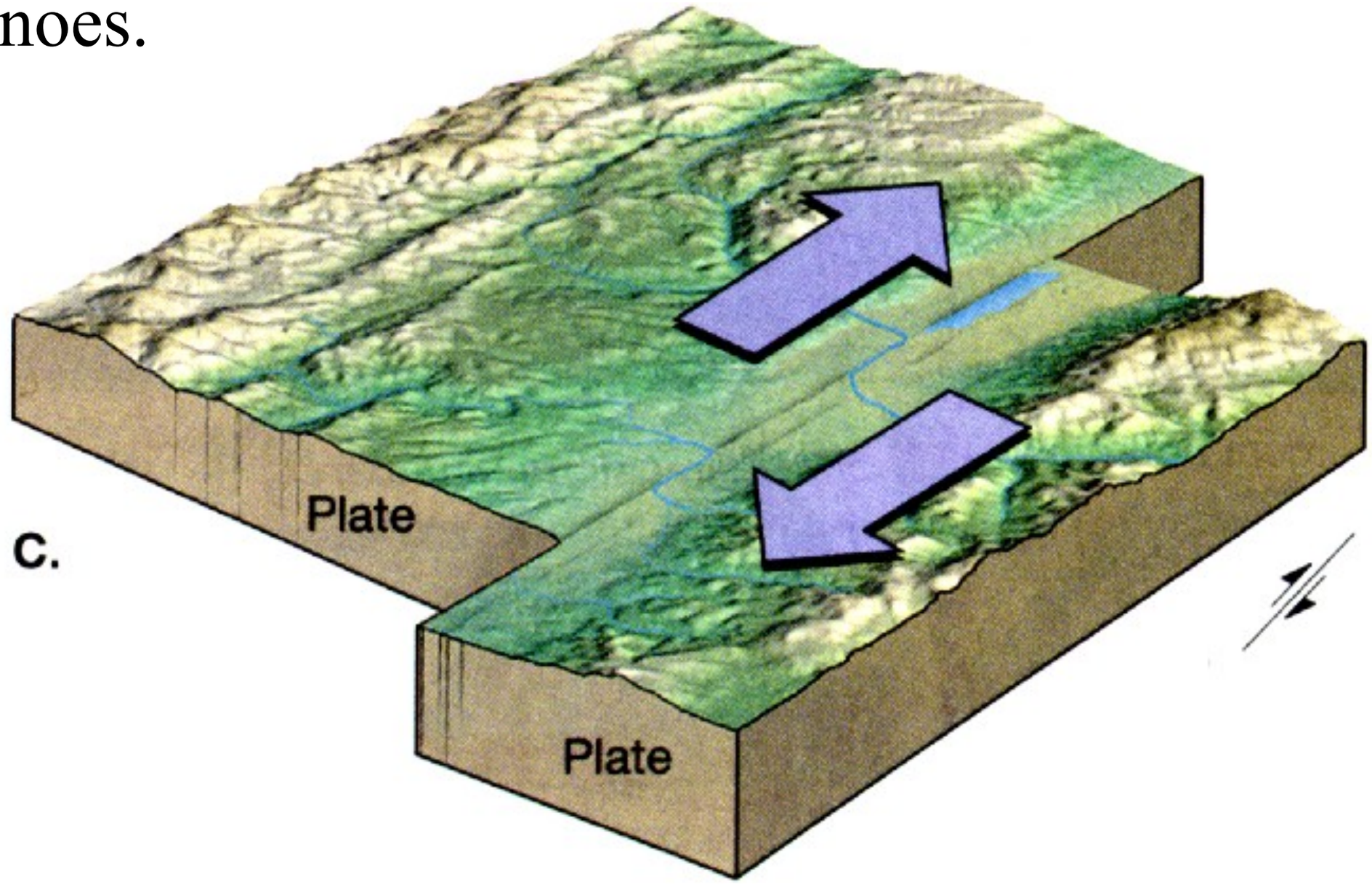
NATIONAL GEOGRAPHIC



TRANSFORM
Plate Boundary

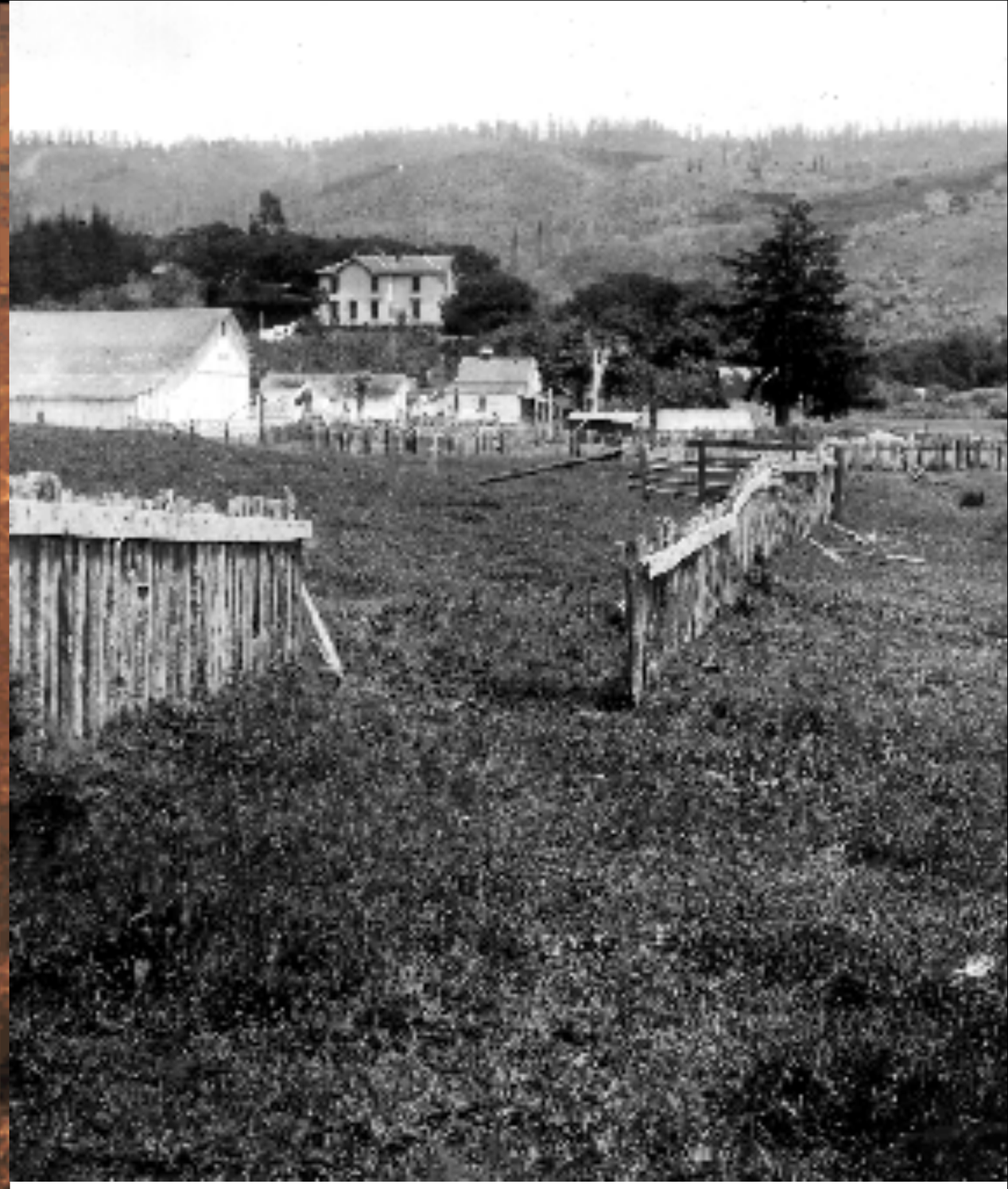
3. <u>TRANSFORM</u> plate boundary

- The plates **SLIDE past** each other.
  - Two plates slide laterally creating a **<u>FAULT</u>**.
  - Causes lots of **<u>Earthquakes</u>**!
  - **NO** volcanoes.



TRANSFORM plate boundary
The San Andreas Fault

- Eg. *The North American Plate* is sliding past the *Pacific Plate*, creating **The San Andreas Fault**, which moves 5cm/ year, and causes all the earthquakes in LA and San Francisco!



San Andreas Fault

1989 and 1994 California Earthquakes

Caused by movement on the San Andreas Fault

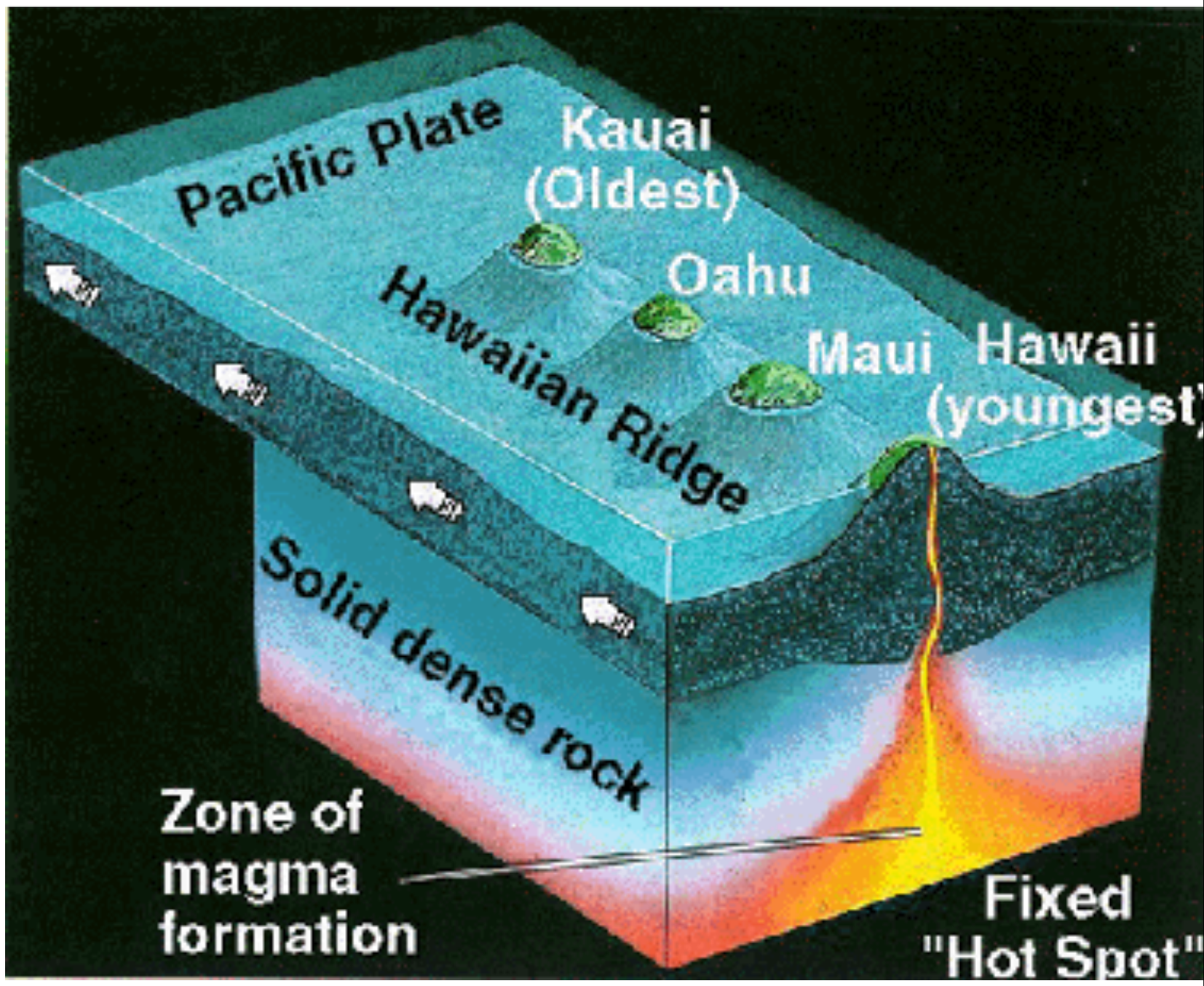
To Remember…

- 3 Types of Plate Boundary:
  - **<u>Divergent</u>** (away from)
    - In **Ocean Crust** => *Ridge* or **Continental Crust** => *Rift*
  - **<u>Convergent</u>** (towards)
    - 3 Types of Converging Boundary
      - **Continental – Continental** => *Mountain Building*
      - **Continental – Oceanic** => *Subduction Zone*
      - **Oceanic – Oceanic** => *Island Arc, Ocean Trench*
  - **<u>Transform</u>** (slide past)

- **Volcanoes** and **Earthquakes** occur at plate boundaries. Which ones?

Hot Spots

- Mantle plumes, huge upward motions of magma in the middle of plates, push up and create volcanic islands.
- As the plate moves, the hotspot below doesn't, resulting in the formation of a chain of islands, each getting older as it moves away from the hotspot



- John Tuzo-Wilson

Tectonic Plates

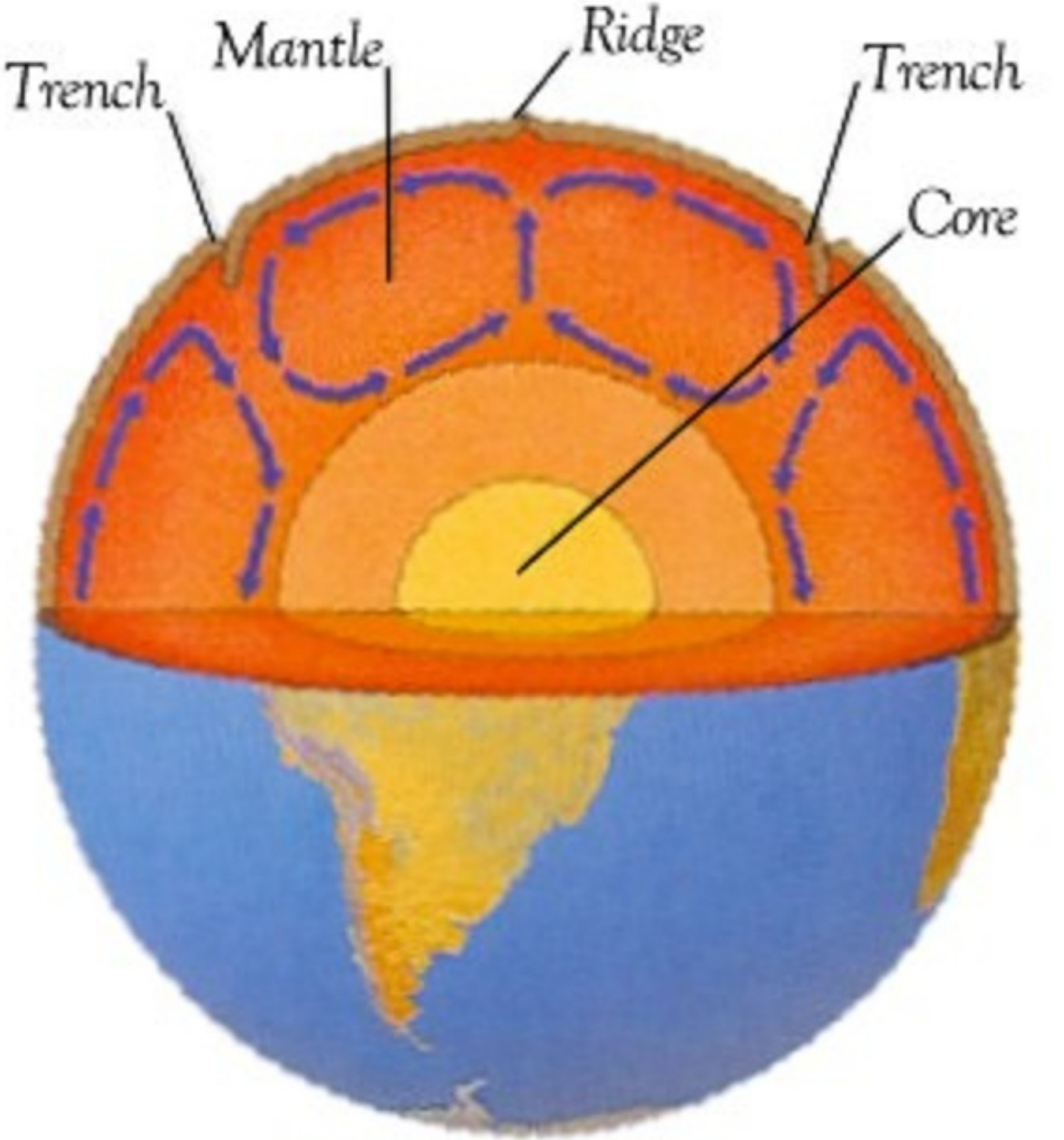
Eurasian Plate
North American Plate
Pacific Plate
Philippine Plate
Indian-Australian Plate
Arabian Plate
African Plate
South American Plate
Nazca Plate
Antarctic Plate
Scotia Plate
Sandwich Plate
Juan de Fuca Plate
Cocos Plate
Caribbean Plate
Fiji Plate

Aleutian Trench
Mariana Trench
Tonga Trench
Peru-Chile Trench
San Andreas Fault
East African Rift
Mid-Indian Ridge
Southwest Indian Ridge
Southeast Indian Ridge
East Pacific Ridge
Mid-Atlantic Ridge

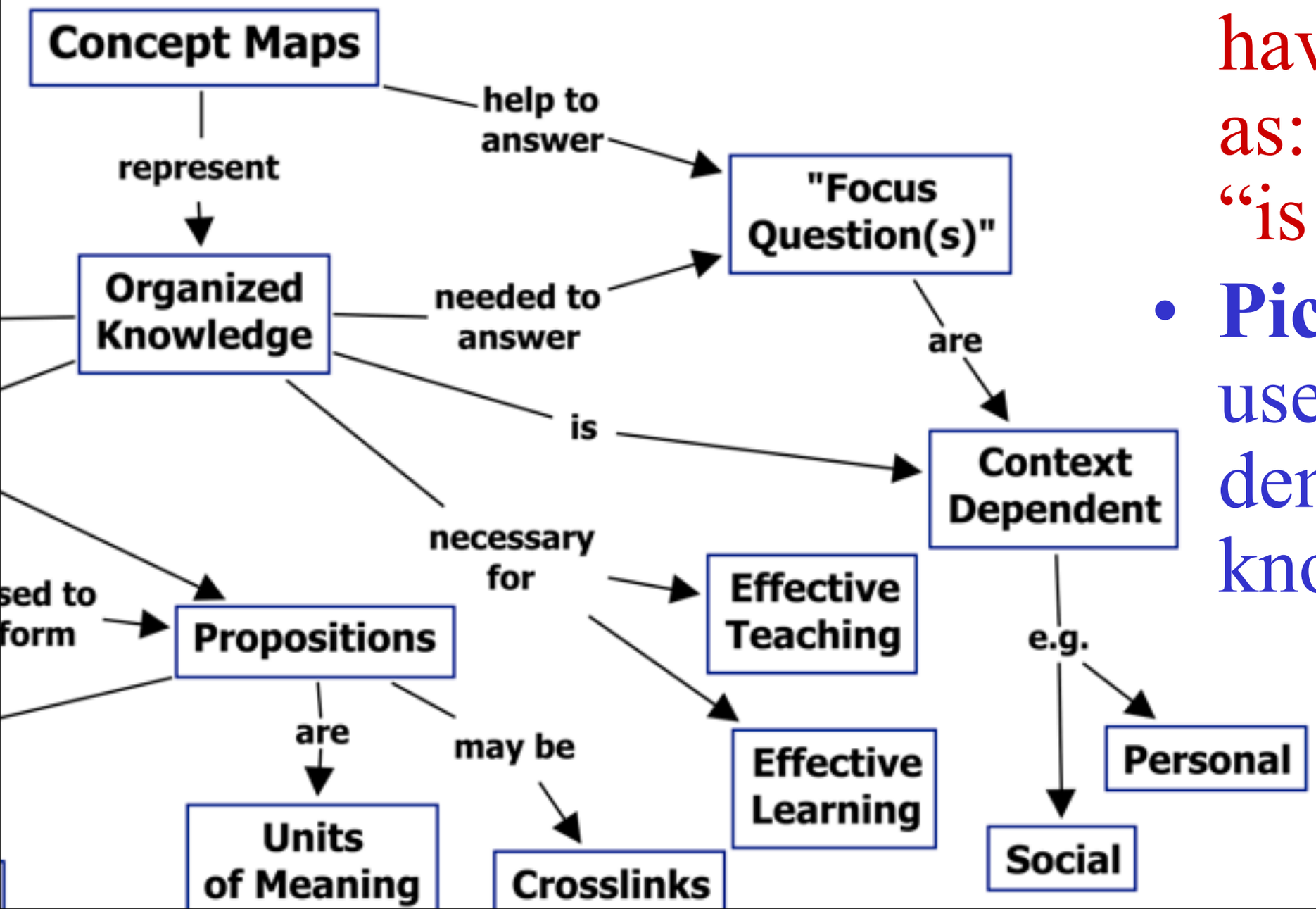
Iceland Hot Spot
Yellowstone Hot Spot
Canary Islands Hot Spot
Hawaii Hot Spot
Galapagos Hot Spot
Easter Island Hot Spot
Tasman Hot Spot
St. Helena Hot Spot
Bouvet Hot Spot

Key

- Relative motion at plate boundary
- Transform plate boundary (transform fault)
- Divergent plate boundary (usually broken by transform faults along mid-ocean ridges)
- Convergent plate boundary (subduction zone) — overriding plate / subducting plate
- Complex or uncertain plate boundary
- Mantle hot spot


Trench
Mantle
Ridge
Trench
Core

Concept Maps



- Show the **relationship** between concepts.
- Connecting lines have **words** such as: “results in” or “is caused by”…
- **Pictures** are also used to demonstrate knowledge.

ELECTRONICS ARE MADE FROM RESOURCES

I want to live in a peaceful world!

So what?

Violence begets more violence

So what?

This supports violent approaches to conflict resolution

So what?

10% of the $ from copper mined in Chile goes to the military

So what?

A lot of Copper is mined in Chile

So what?

#1 Copper is an efficient conductor of electricity

So what?

Using copper helps us to save energy

Cu = ★

So what?

Less energy means less fossil fuel emissions

So what?

Burning fossil fuels contributes to climate change

So what?

In Canada, our winters are getting warmer

So what?

I'm worried my kids won't be able to have the same fun as I did — playing pond hockey.

So what?

FOSSIL FUELS like Coal, oil & natural gas are often used as sources of energy

So what?

A lot of energy is required to make, transport, use & dispose of electronics.

So what?

We could use SOLAR or WIND energy instead

So what?

These technologies are economically expensive.

So what?

I may have to decrease my energy use

So what?

Some of my friends have moved to other cities to look for work

So what?

People working at the mill might lose their jobs

$?

So what?

Paper mills might be shut down

So what?

Recycled paper could be used instead

So what?

Paper products are used to package electronics

So what?

Fewer trees would need to be cut down

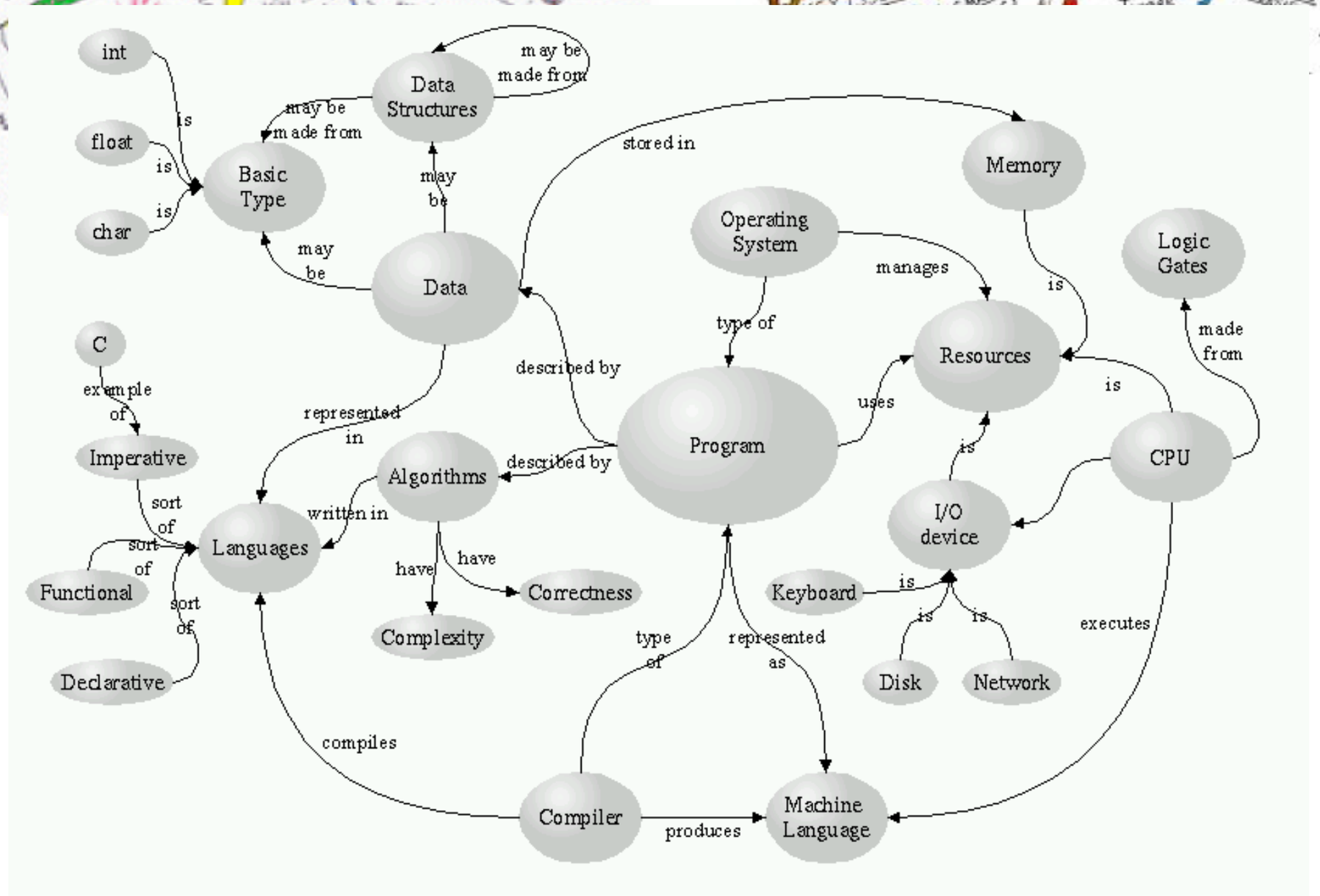
So what?

This would save & protect the homes of the animals that live in the forest.

So what?

I like to see moose, bears, ruby-throated hummingbirds & other wildlife when I go on canoe trips with my family.


TIME
MANAGEMENT
CLARITY
MOTIVATION
APPRECIATION
SIMPLIFICATION
DELEGATION
MONITORING
PROGRESS
FOLLOW-UP
BALANCE
NEGOTIATION
TODAY
COMMUNICATION
FEEDBACK
SUPPORT
PRAISE
REVIEW
CORRECTION
IMPROVE
ERGONOMIC
USER-FRIENDLY
EFFICIENT
VALUE-ADDED
POSITIVE
WORK-LIFE BALANCE
WELL-BEING
LET GO
FEARLESS
EXCEED EXPECTATIONS
TRANSCEND LIMITS
CONFIDENCE
SUPERVISE
HELP
ENCOURAGE
DISCUSSION
BIG PICTURE
CHUNKING
BITE-SIZED
MULTI-TASKING
DIVERSITY
CHOICES
DECISIONS
BIG
SMALL
DE-CLUTTER
BREAKS
WHO
WHAT
KEY ISSUES


int
float
char
is
is
is
Basic Type
Data Structures
may be made from
may be made from
may be
may be
Data
stored in
Memory
Operating System
manages
type of
Logic Gates
is
made from
Resources
is
uses
Program
described by
described by
represented in
Algorithms
written in
Languages
C
example of
Imperative
sort of
sort of
sort of
Functional
Declarative
have
have
Correctness
Complexity
CPU
is
I/O device
Keyboard
is
is
is
Disk
Network
executes
type of
represented as
compiles
Compiler
produces
Machine Language