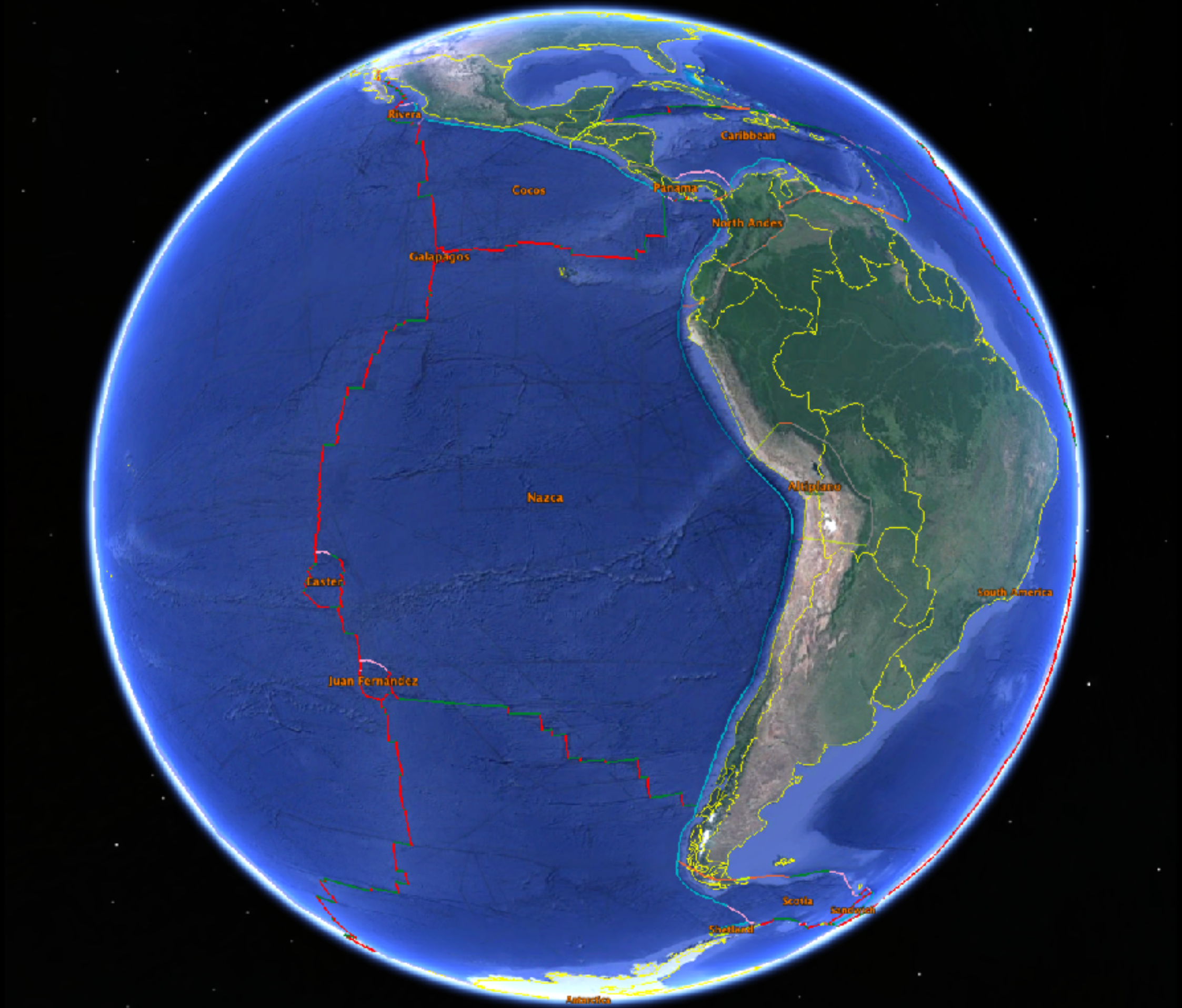
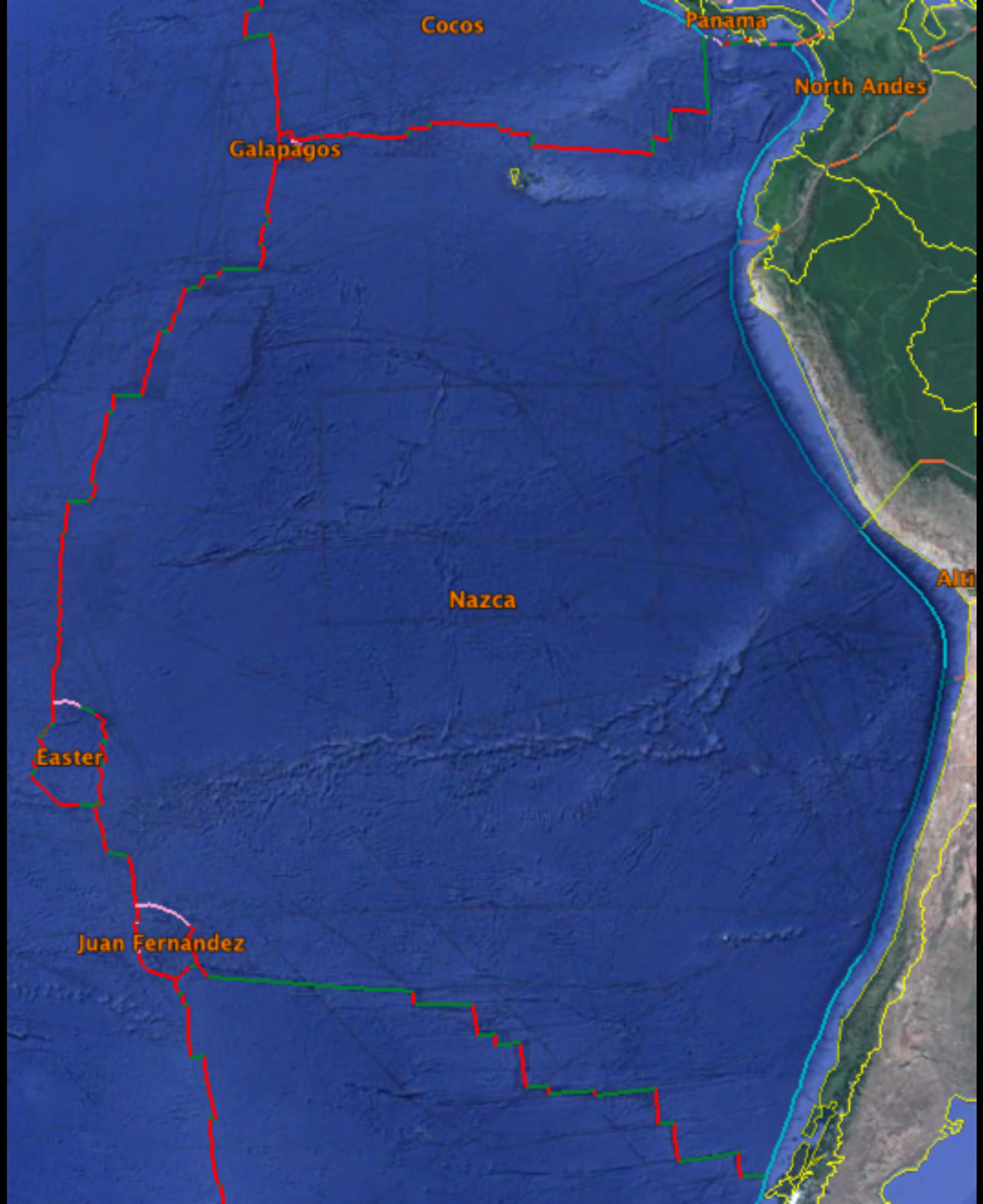

Rivera
Caribbean
Cocos
Panama
North Andes
Galapagos
Nazca
Altiplano
Easter
South America
Juan Fernandez
Scotia
Sandwich
Shetland
Antarctica


Cocos
Panama
North Andes
Galapagos
Nazca
Easter
Juan Fernandez

NEATLY--

1. Label the plates: Nazca, South America, Antarctica, Pacific, Cocos
2. Label the Nazca-Cocos Ridge, Nazca-Pacific Ridge, and Nazca-Antarctic Ridge
3. Draw arrows on both side of axial rifts along the mid-ocean ridges
4. Draw half-arrow pairs along the longer transform faults on each ridge
5. Draw barbs along the Nazca-Pacific Trench on the upper (South American) plate

Explanation

axial rift

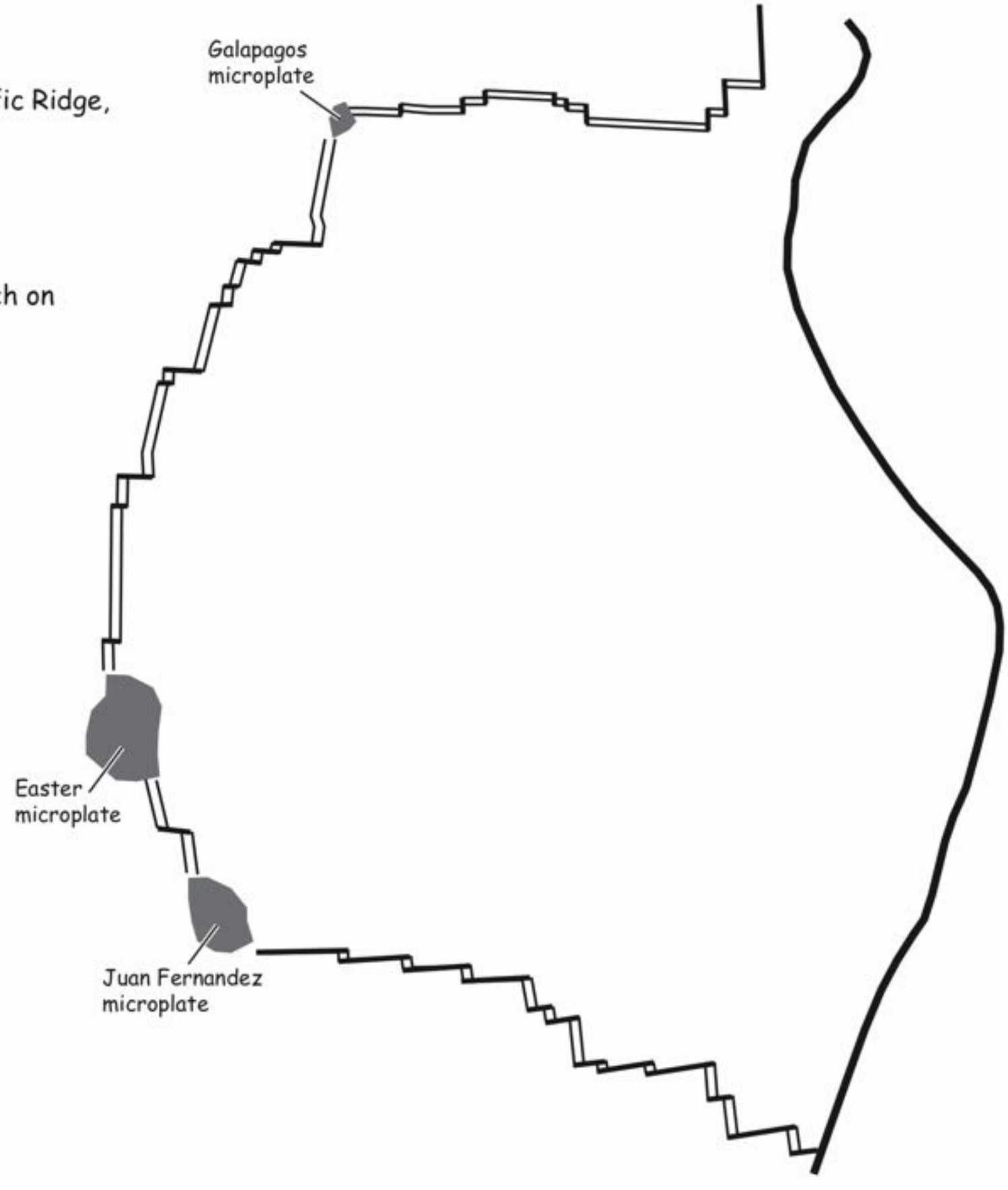
trench, with barbs on the upper plate

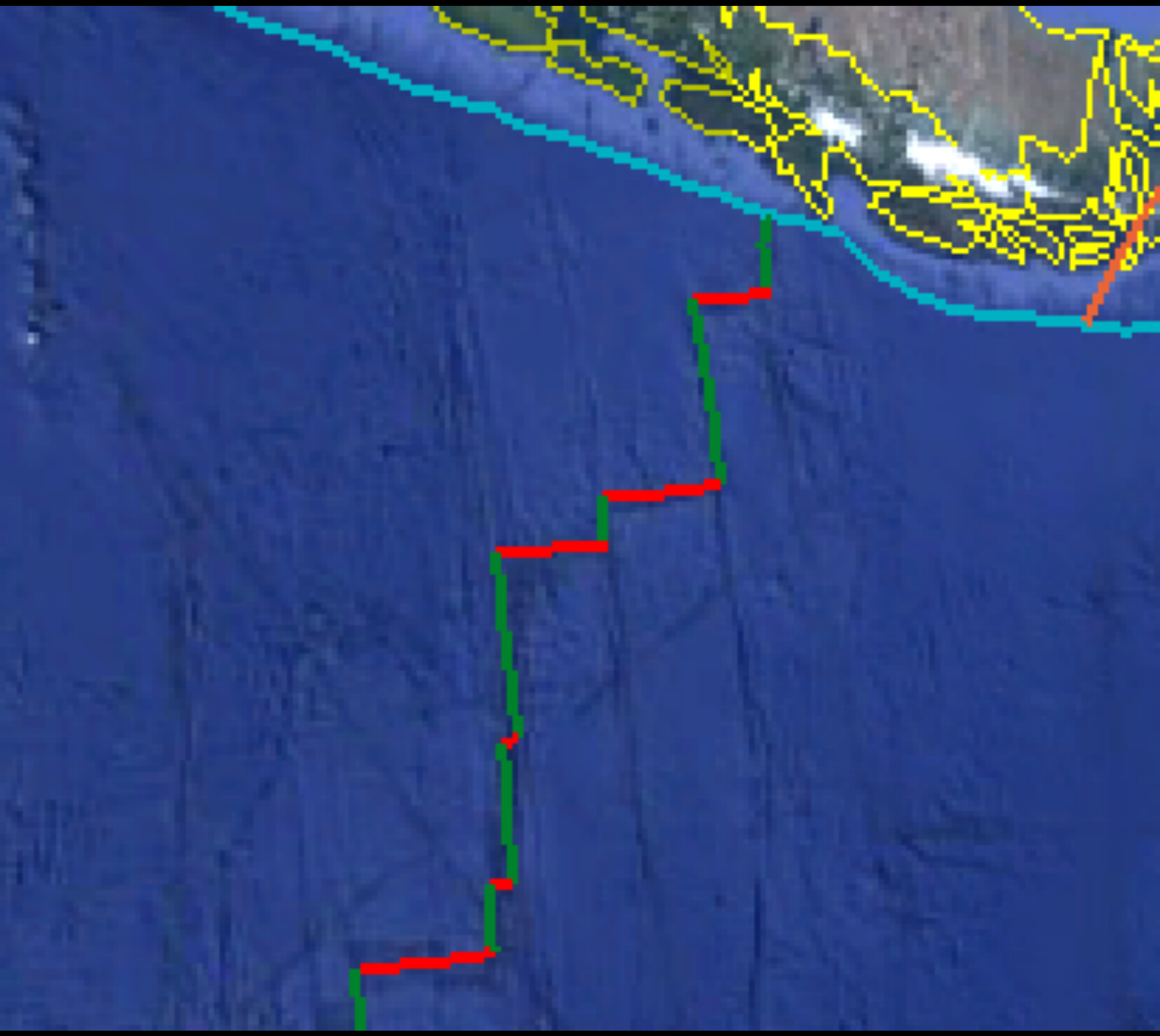
right-lateral **transform fault**

left-lateral **transform fault**

leader, used for labels

arrow, used for velocity vectors or to indicate motion





NEATLY--

1. Label the plates: Nazca, South America, Antarctica
2. Label the Nazca-Antarctic Ridge and the trench
3. Draw barbs along the trench
4. Indicate relative motion across plate boundaries

- Draw arrows on both side of axial rifts along the mid-ocean ridge
- Draw half-arrow pairs along the longer transform faults
- Draw arrows on both sides of the trench

Explanation

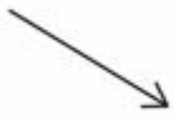
axial rift

trench, with barbs on the upper plate

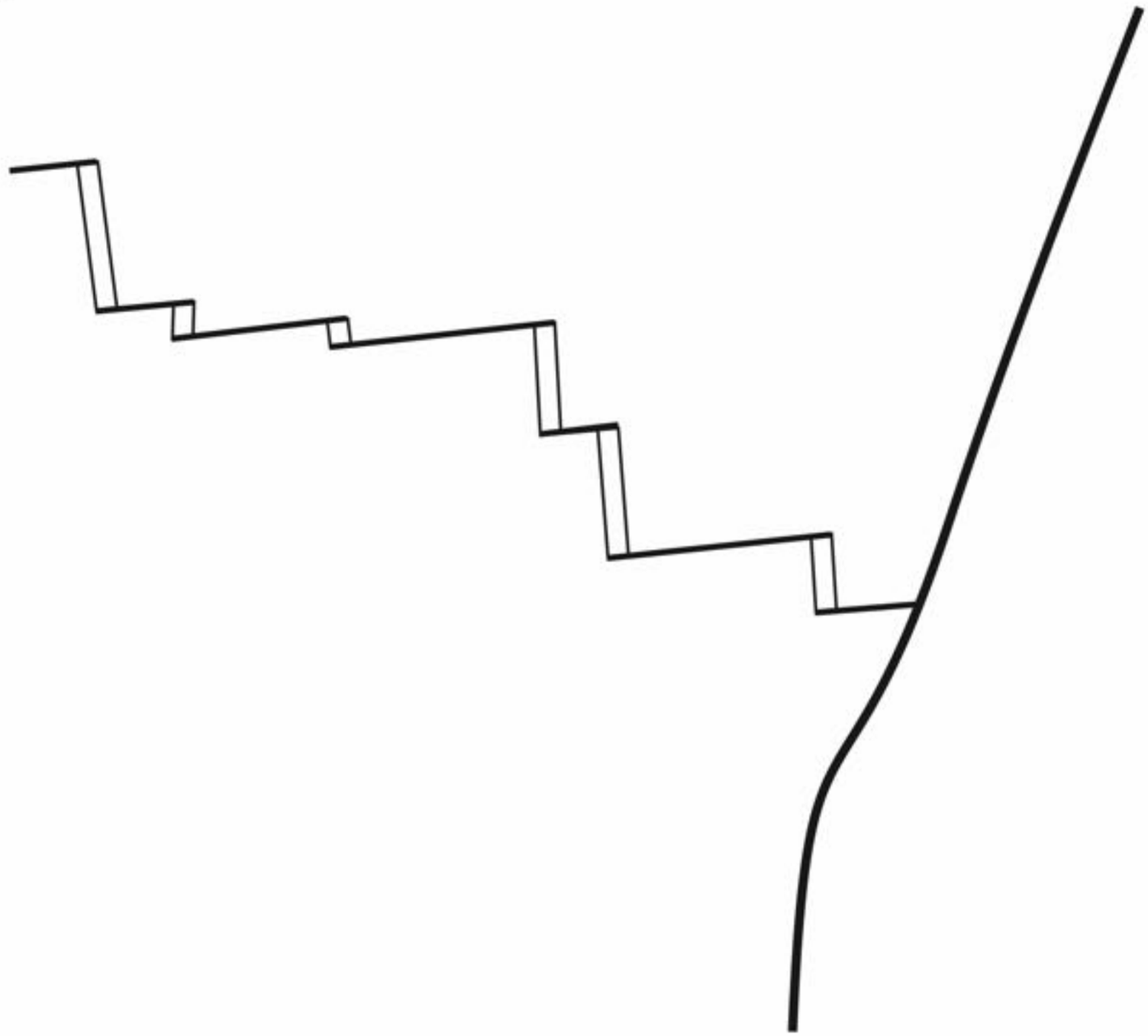
right-lateral **transform fault**

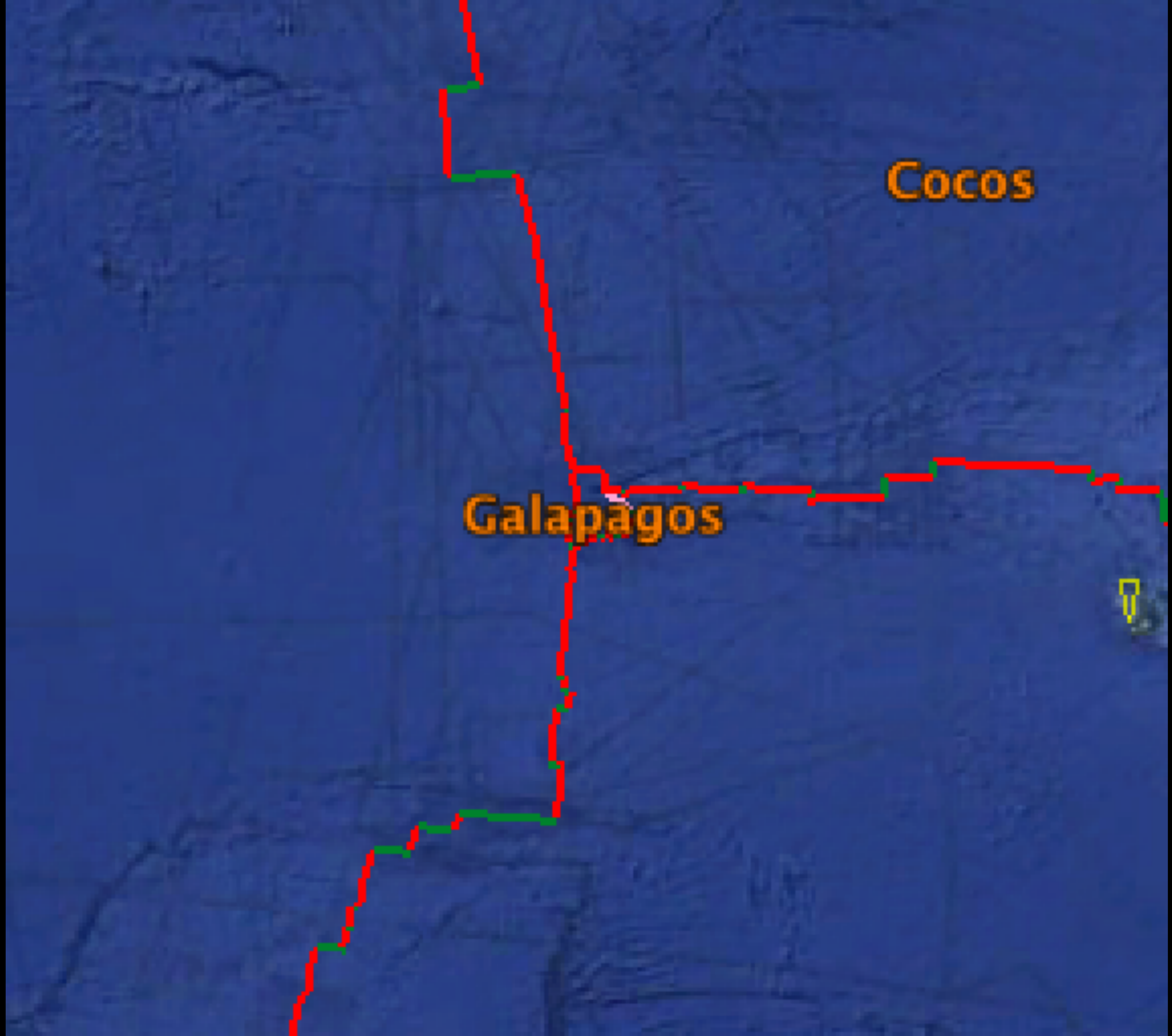
left-lateral **transform fault**

leader, used for labels



arrow, used for velocity vectors or to indicate motion




Cocos
Galapagos


Juan de Fuca
North America
Rivera
Caribbean
Cocos
Galapagos
Panama
North Andes

NEATLY--

1. Label the plates: North America, Eurasia, Africa, South America, Caribbean, Cocos, Rivera, Pacific, Juan de Fuca
2. Label the Atlantic Ridge, Arctic Ridge, Aleutian Trench, Cascadia Trench, Middle American Trench, Queen Charlotte Fault, San Andreas Fault system
3. Draw barbs along the trench
4. Indicate relative motion across plate boundaries

- Draw arrows on both side of axial rifts along the mid-ocean ridge
- Draw half-arrow pairs along the longer transform faults
- Draw arrows on both sides of the trench

Explanation

axial rift

trench, with barbs on the upper plate

right-lateral **transform fault**

left-lateral **transform fault**

star

leader, used for labels

arrow, used for velocity vectors or to indicate motion

NEATLY--

1. Label the plates: North America, Eurasia, Africa, South America, Caribbean, Cocos, Rivera, Pacific, Juan de Fuca
2. Label the Atlantic Ridge, Arctic Ridge, Aleutian Trench, Cascadia Trench, Middle American Trench, Queen Charlotte Fault, San Andreas Fault system
3. Draw barbs along the trench
4. Indicate relative motion across plate boundaries

- Draw arrows on both side of axial rifts along the mid-ocean ridge
- Draw half-arrow pairs along the longer transform faults
- Draw arrows on both sides of the trench

Explanation

axial rift

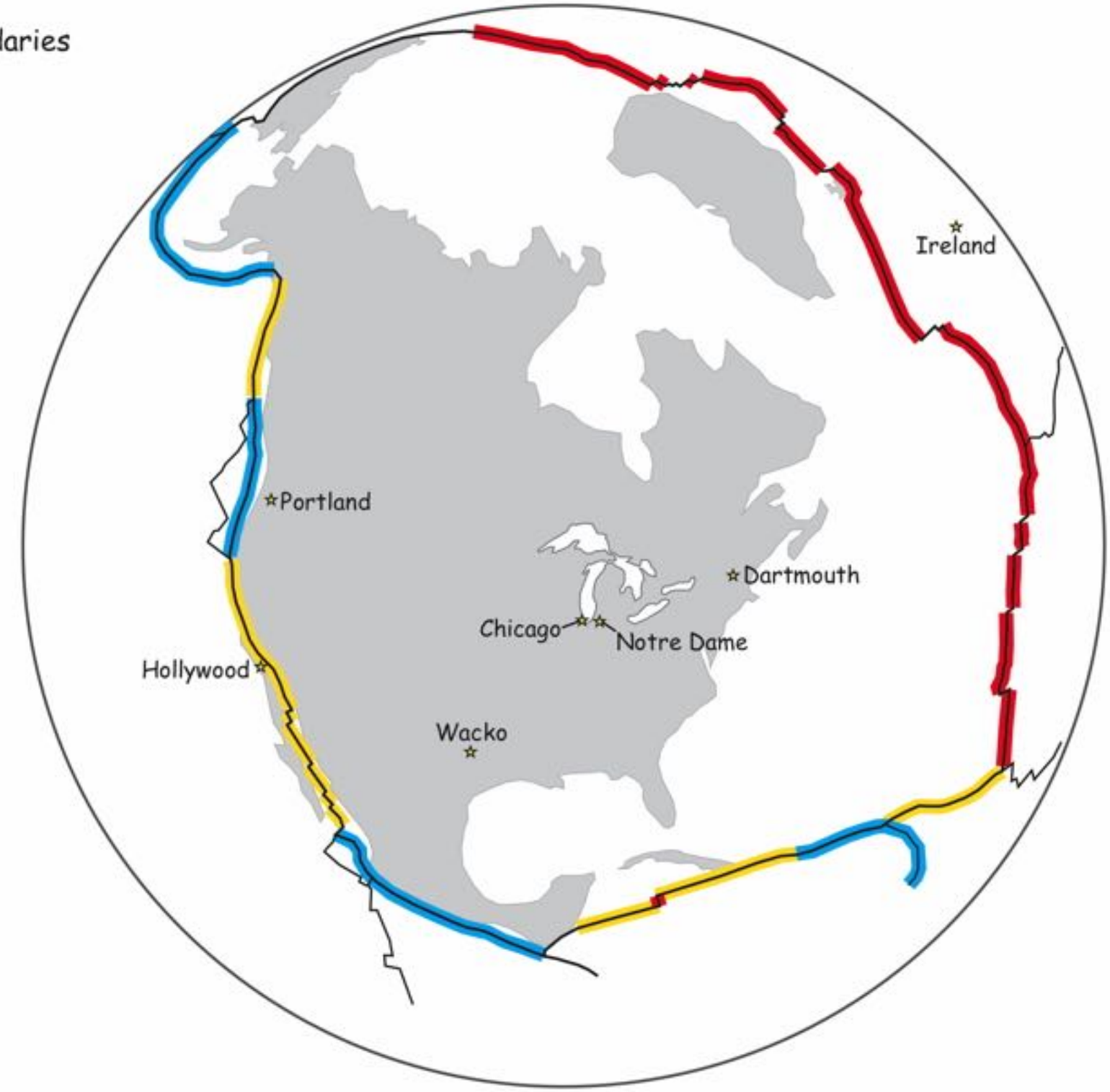
trench, with barbs on the upper plate

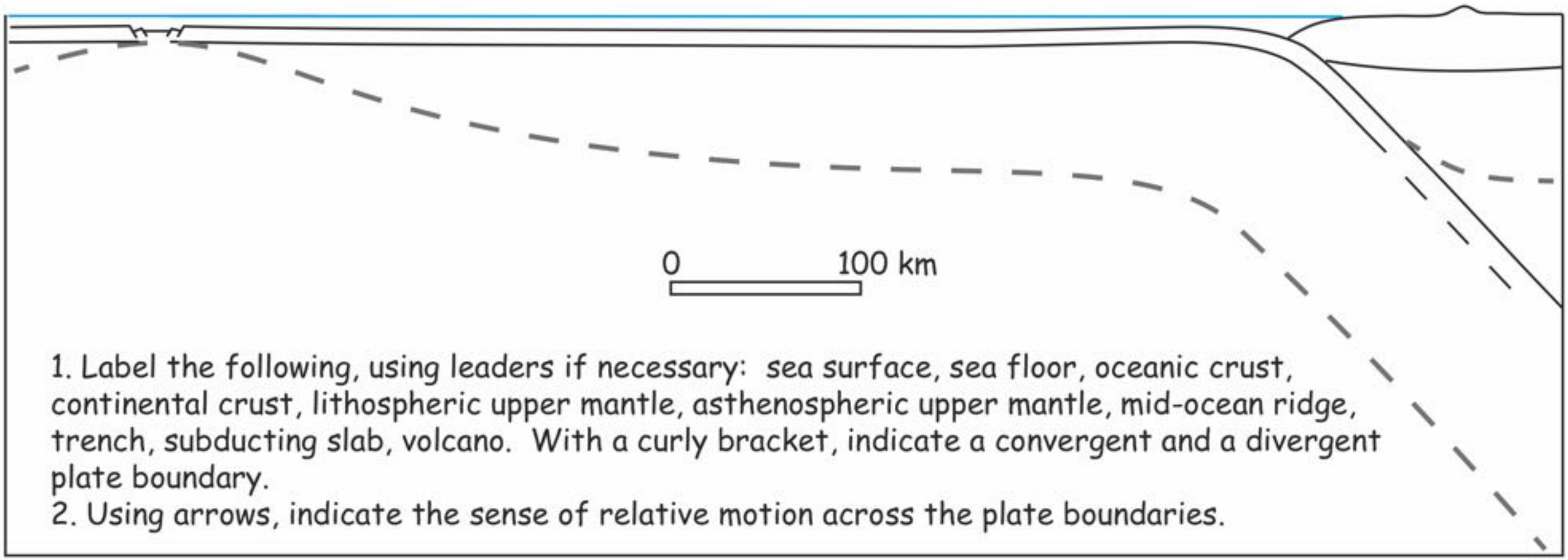
right-lateral **transform fault**

left-lateral **transform fault**

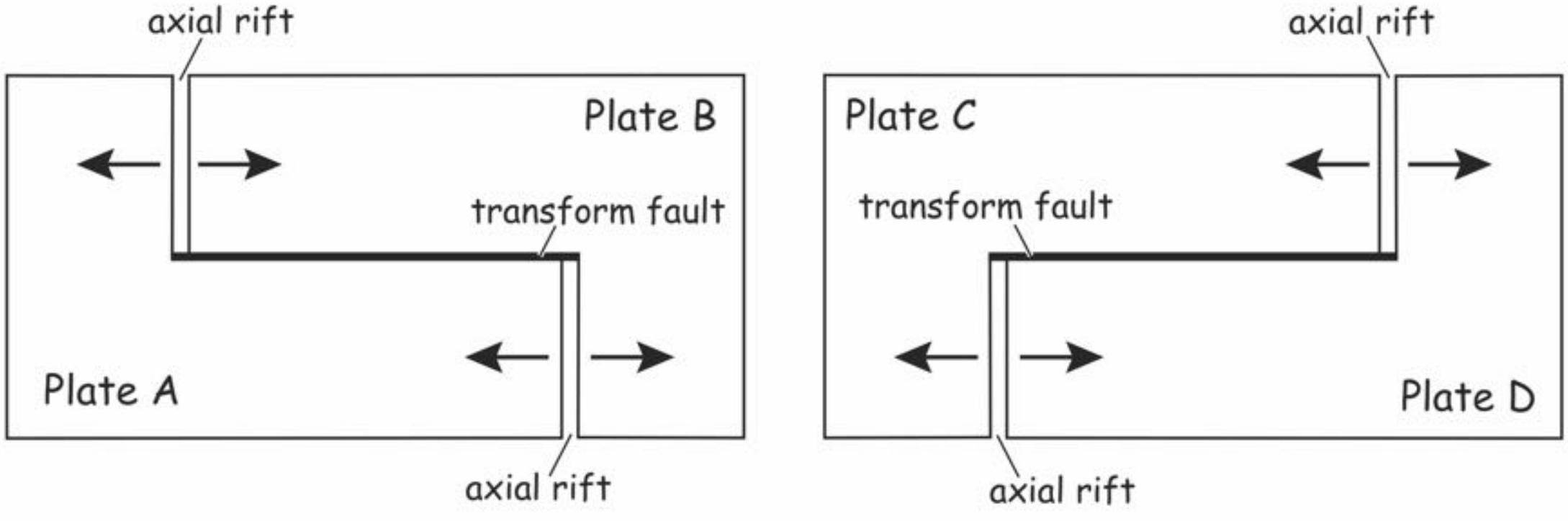
leader, used for labels

arrow, used for velocity vectors or to indicate motion



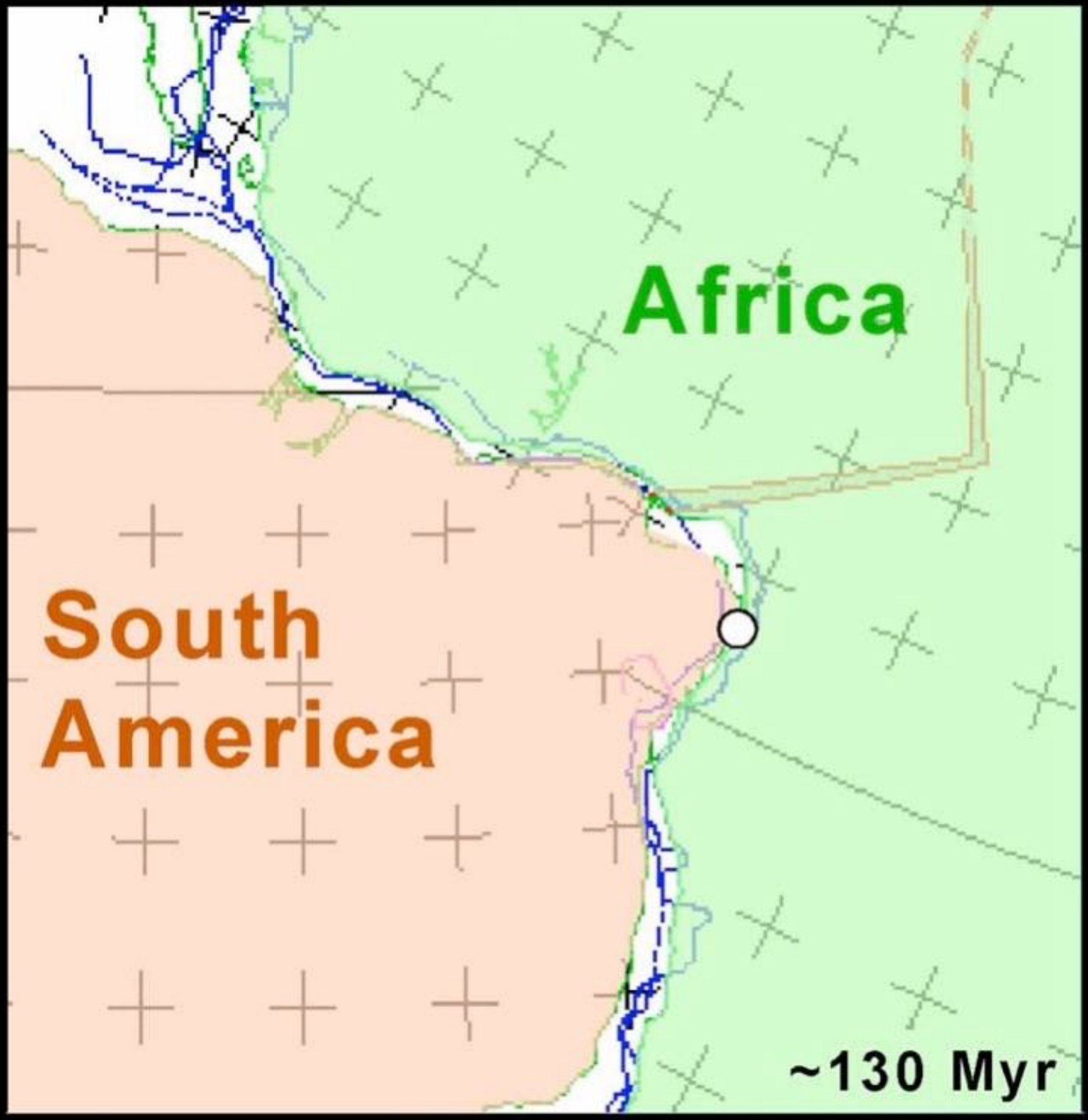


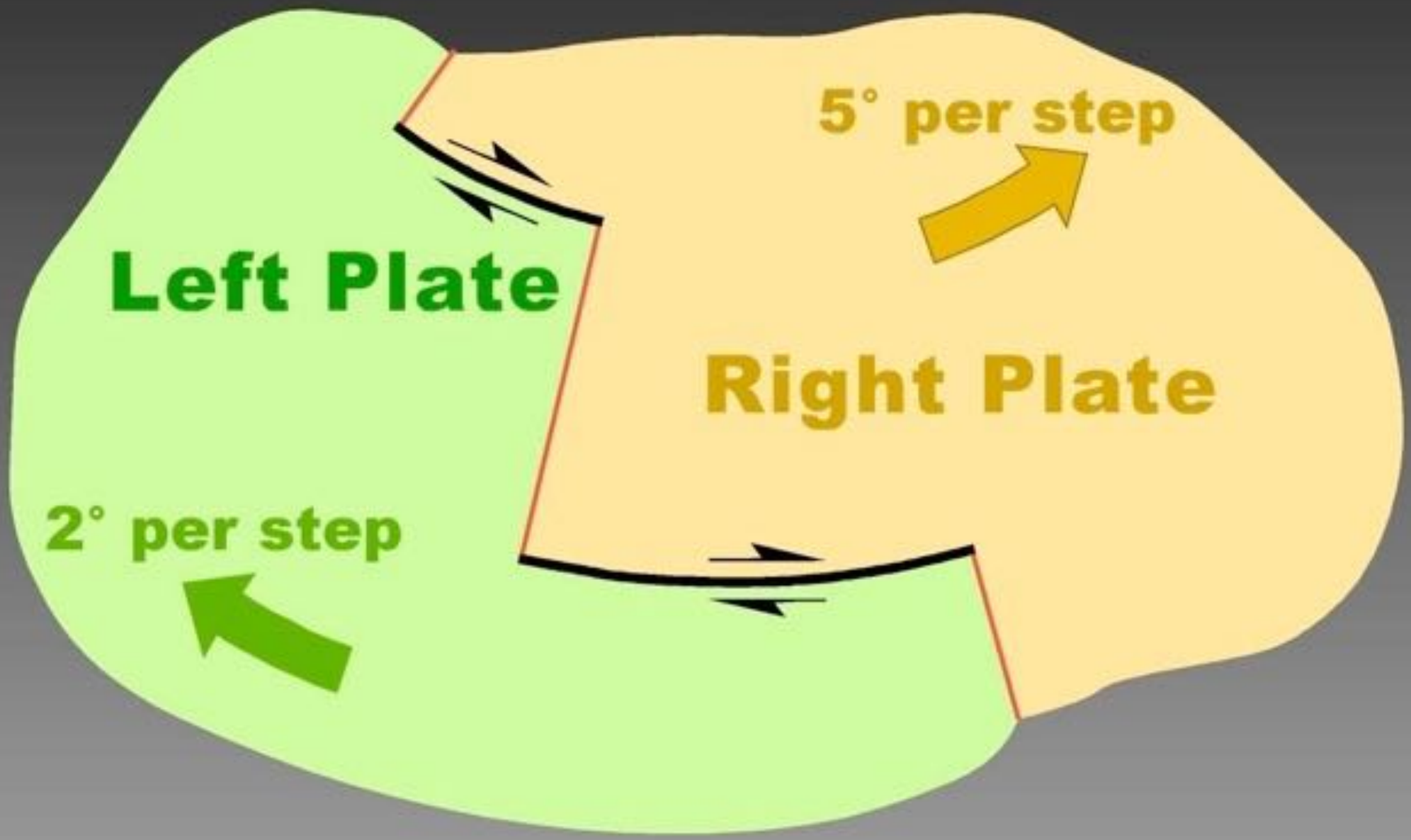
1. Label the following, using leaders if necessary: sea surface, sea floor, oceanic crust, continental crust, lithospheric upper mantle, asthenospheric upper mantle, mid-ocean ridge, trench, subducting slab, volcano. With a curly bracket, indicate a convergent and a divergent plate boundary.
2. Using arrows, indicate the sense of relative motion across the plate boundaries.

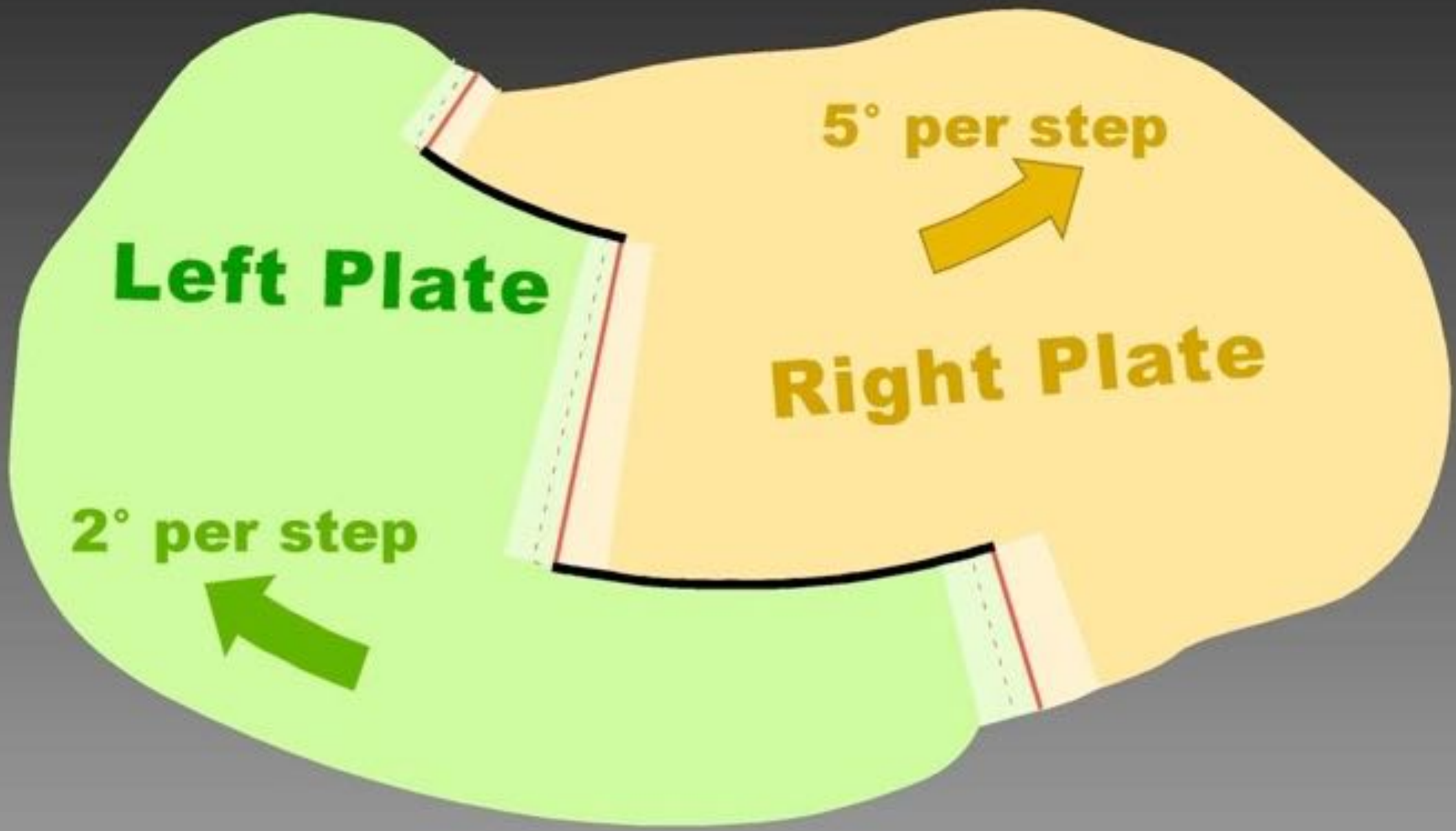


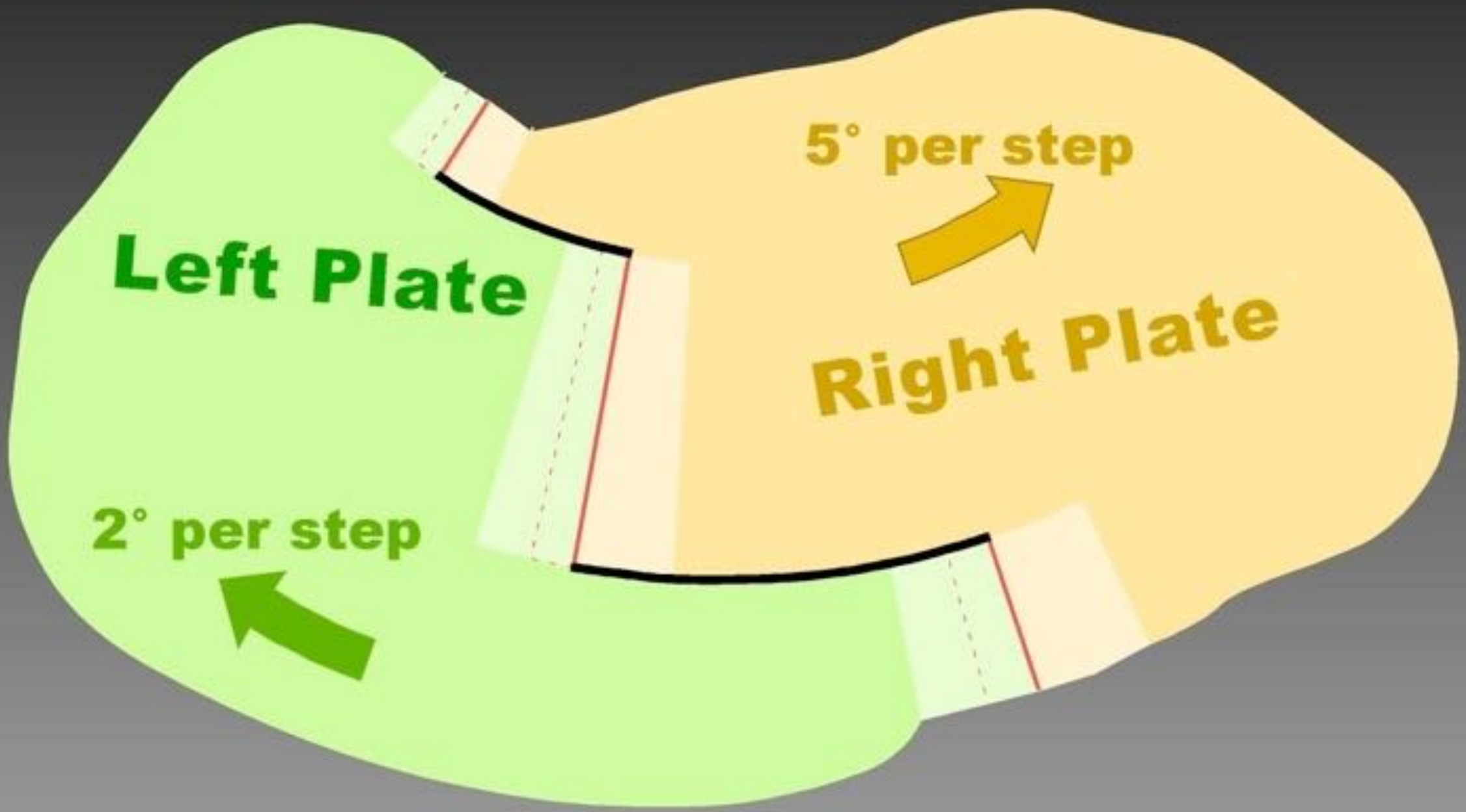
Using half-arrow pairs, indicate the sense of relative motion across the transform fault plate boundaries.

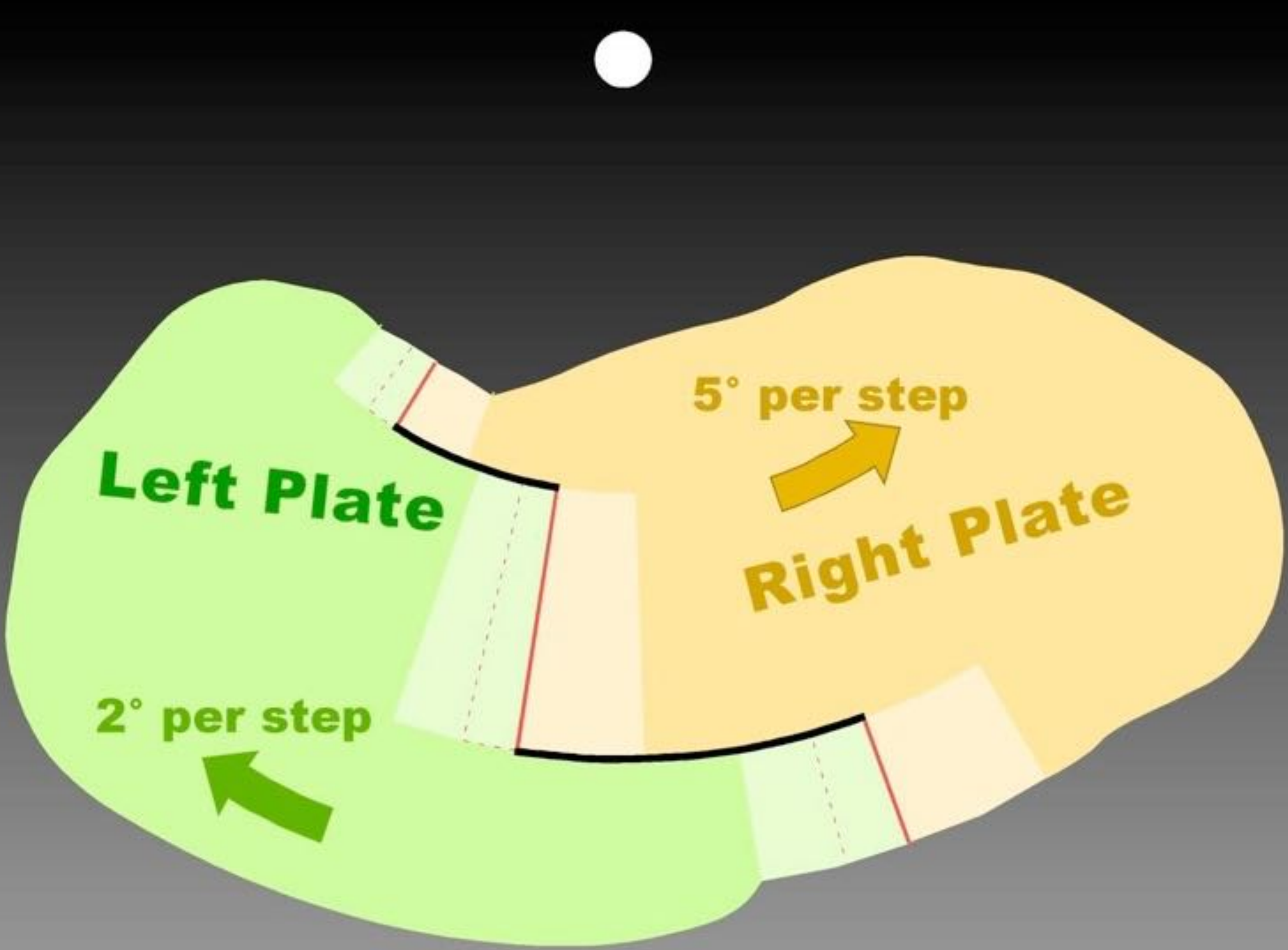

Continental shelf
Modern Equator
SOUTH AMERICA
AFRICA
Modern Equator

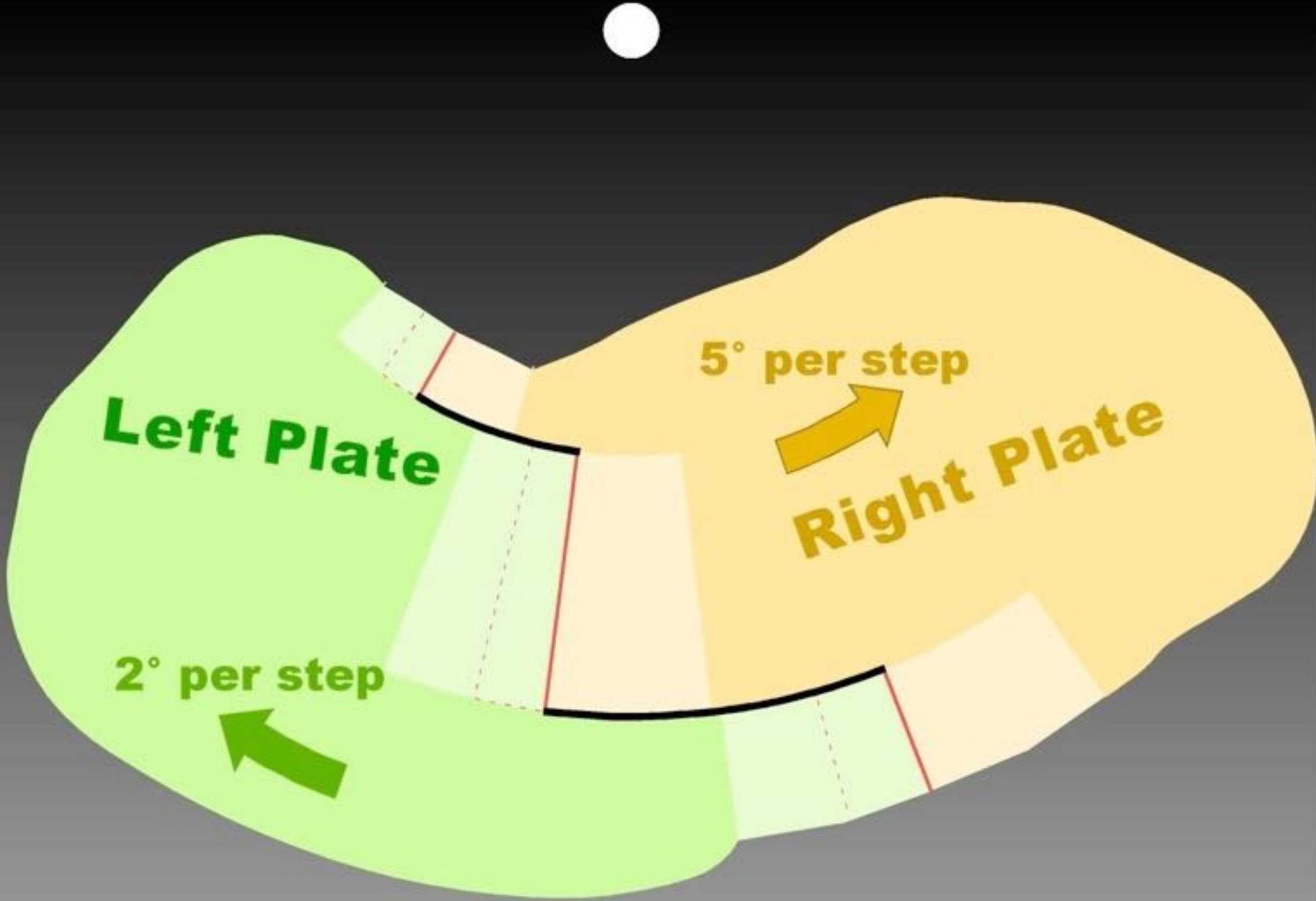

Africa
South America
~130 Myr

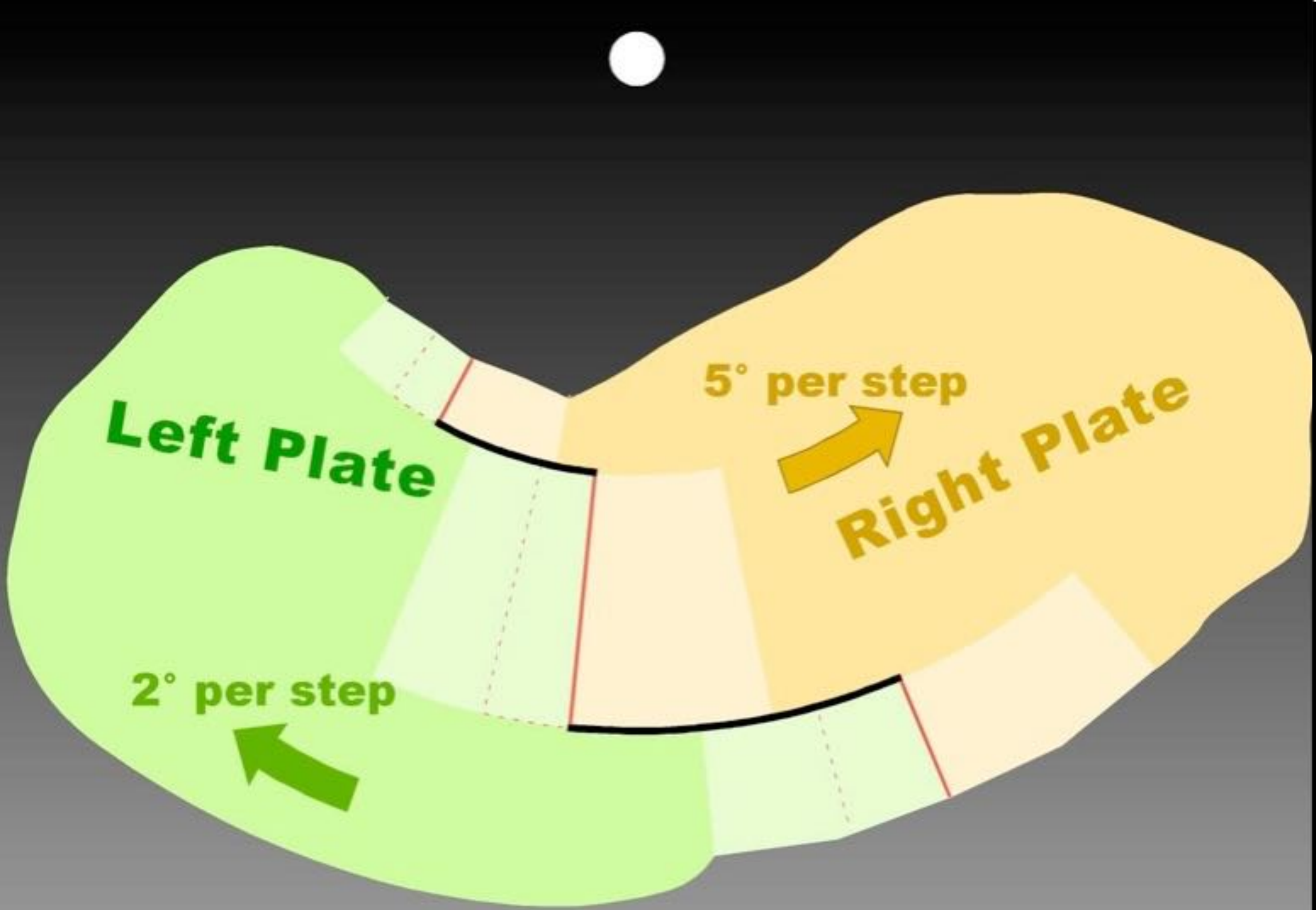

5° per step
Left Plate
Right Plate
2° per step


5° per step
Left Plate
Right Plate
2° per step


Left Plate
2° per step
5° per step
Right Plate


Left Plate
2° per step
5° per step
Right Plate


Left Plate
2° per step
5° per step
Right Plate


Left Plate
5° per step
Right Plate
2° per step

Detecting plate motion

- Motion of plate relative to adjacent plates

Detecting plate motion

- Motion of plate relative to adjacent plates
- Motion of plate relative to hot spots

Detecting plate motion

- Motion of plate relative to adjacent plates
- Motion of plate relative to hot spots
- VLBI: Very Long Baseline Interferometry

Detecting plate motion

- Motion of plate relative to adjacent plates
- Motion of plate relative to hot spots
- VLBI: Very Long Baseline Interferometry
- SLR: Satellite Laser Rangefinding

Detecting plate motion

- Motion of plate relative to adjacent plates
- Motion of plate relative to hot spots
- VLBI: Very Long Baseline Interferometry
- SLR: Satellite Laser Rangefinding
- GPS: Global Positioning System

Why do plates move?

Gravity provides the force responsible for plate motion.

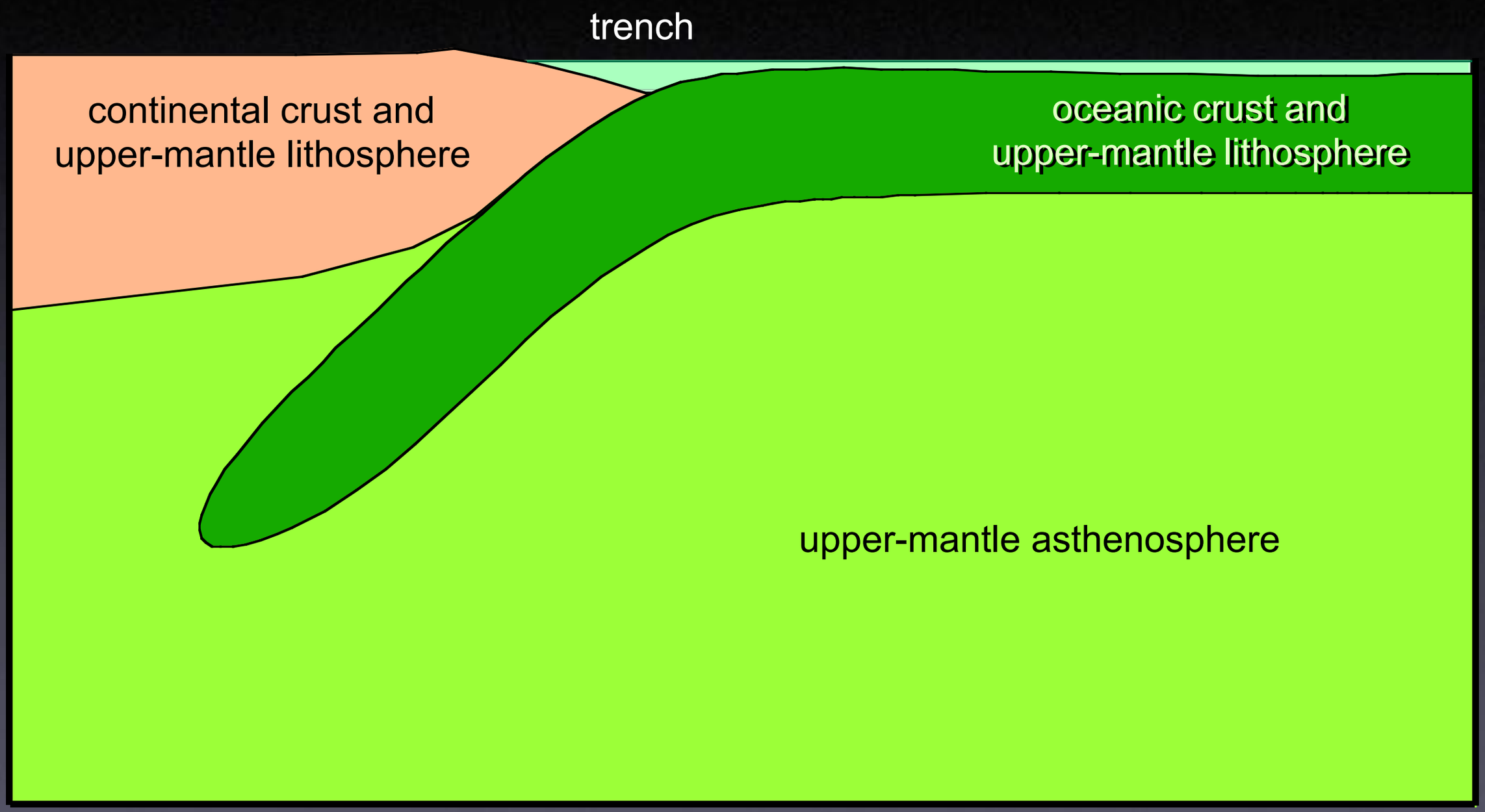
Some Other Important Variables:

- Density variations
- Strength
- Rheology

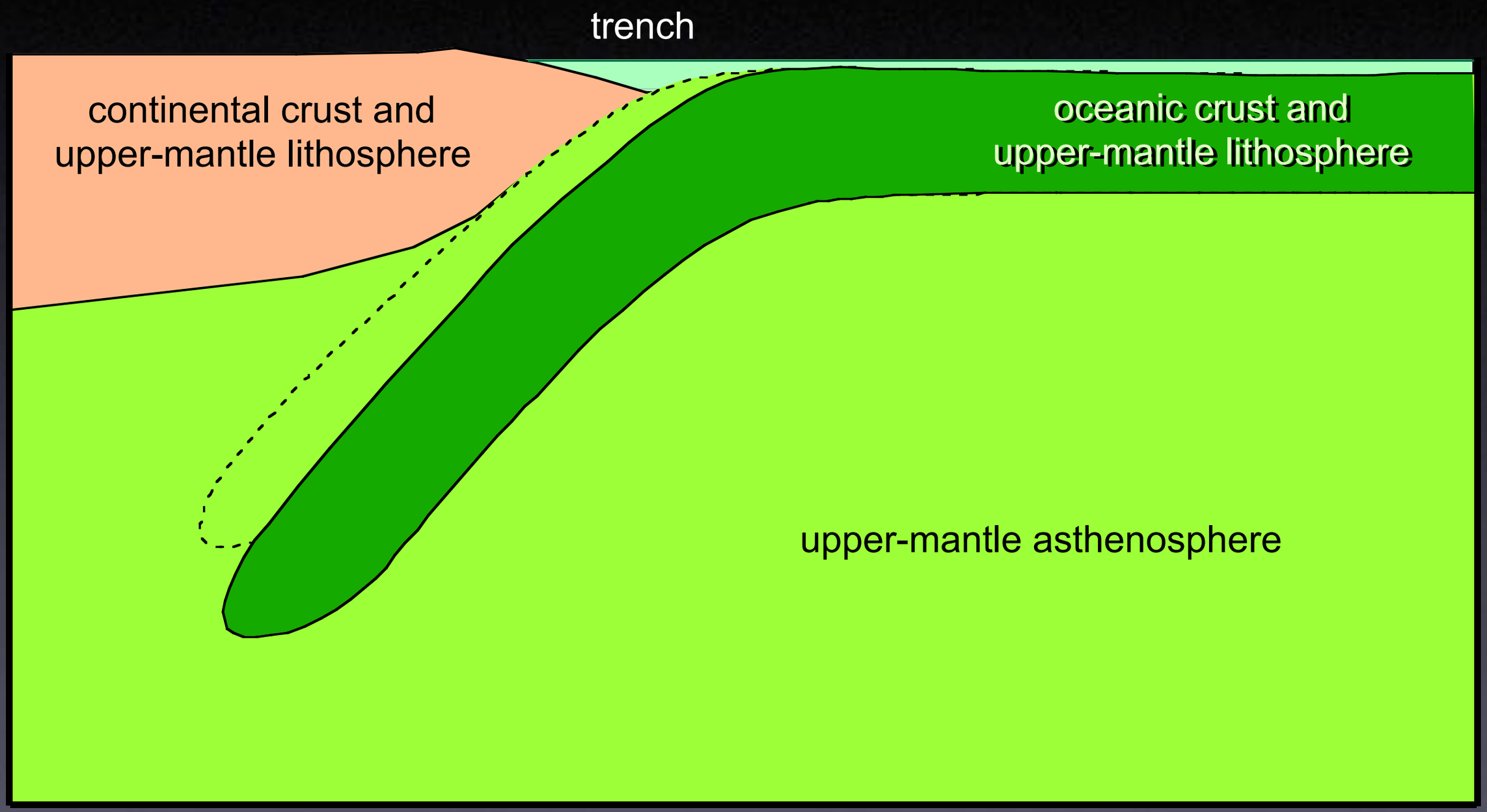
Why do plates move?

- **Slab pull** (most important)
- **Ridge push** (important)
- **Trench pull** or asthenosphere counterflow (locally import)
- **Convection**: viscous drag by a convecting mantle (?)
- Eötvös force, et cetera

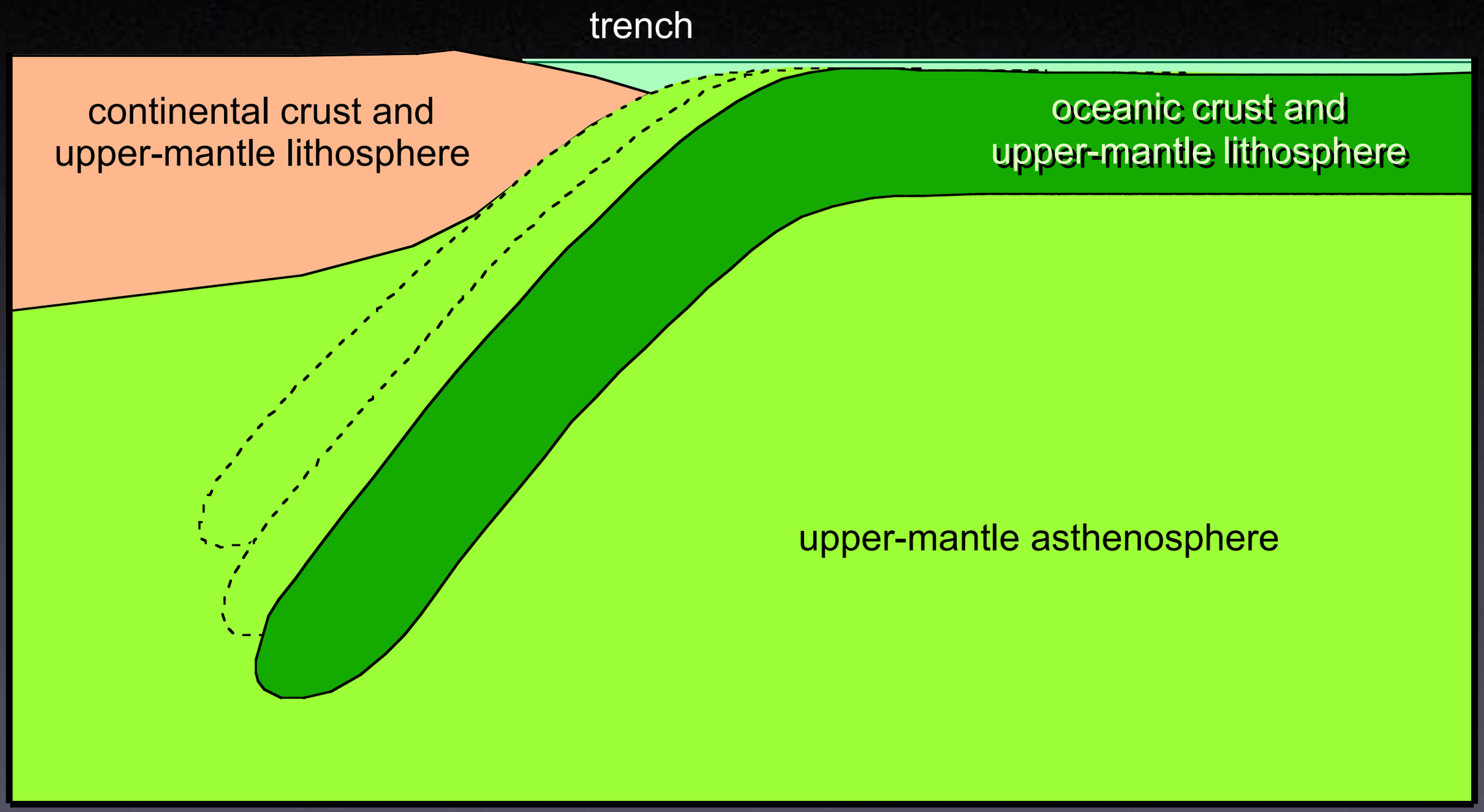
Slab Pull


trench
continental crust and
upper-mantle lithosphere
oceanic crust and
upper-mantle lithosphere
upper-mantle asthenosphere

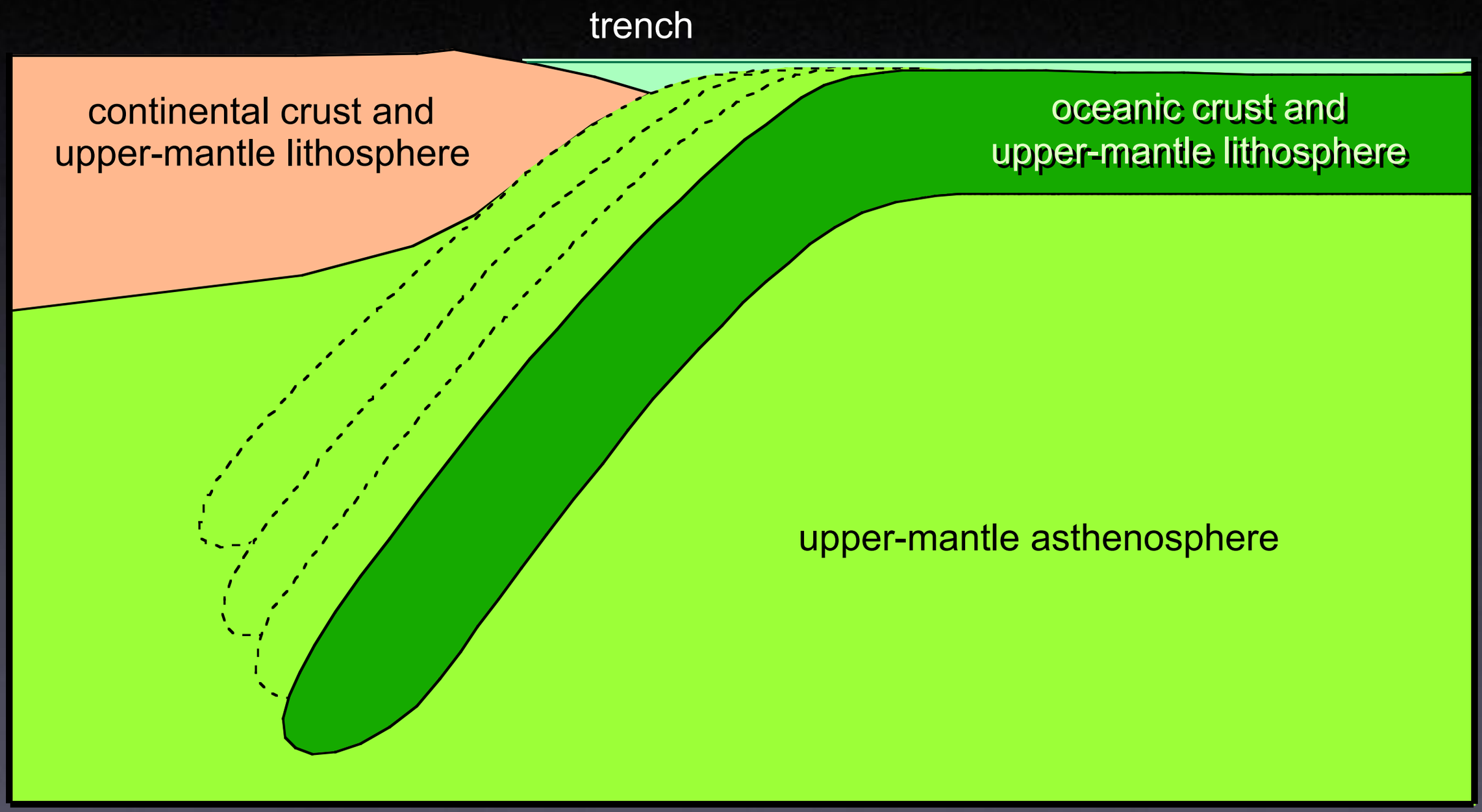
Slab Pull


trench
continental crust and
upper-mantle lithosphere
oceanic crust and
upper-mantle lithosphere
upper-mantle asthenosphere

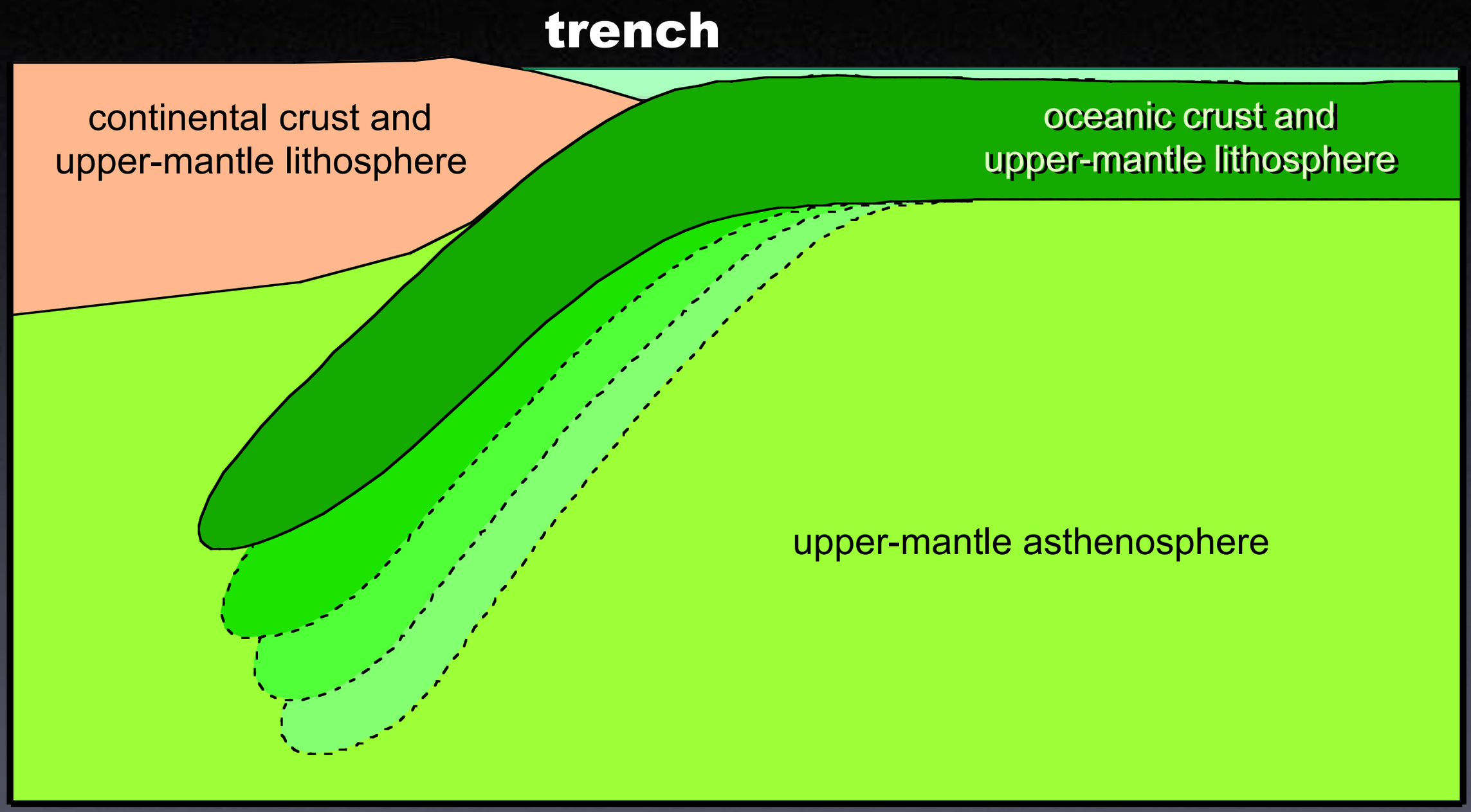
Slab Pull


trench
continental crust and
upper-mantle lithosphere
oceanic crust and
upper-mantle lithosphere
upper-mantle asthenosphere

Slab Pull

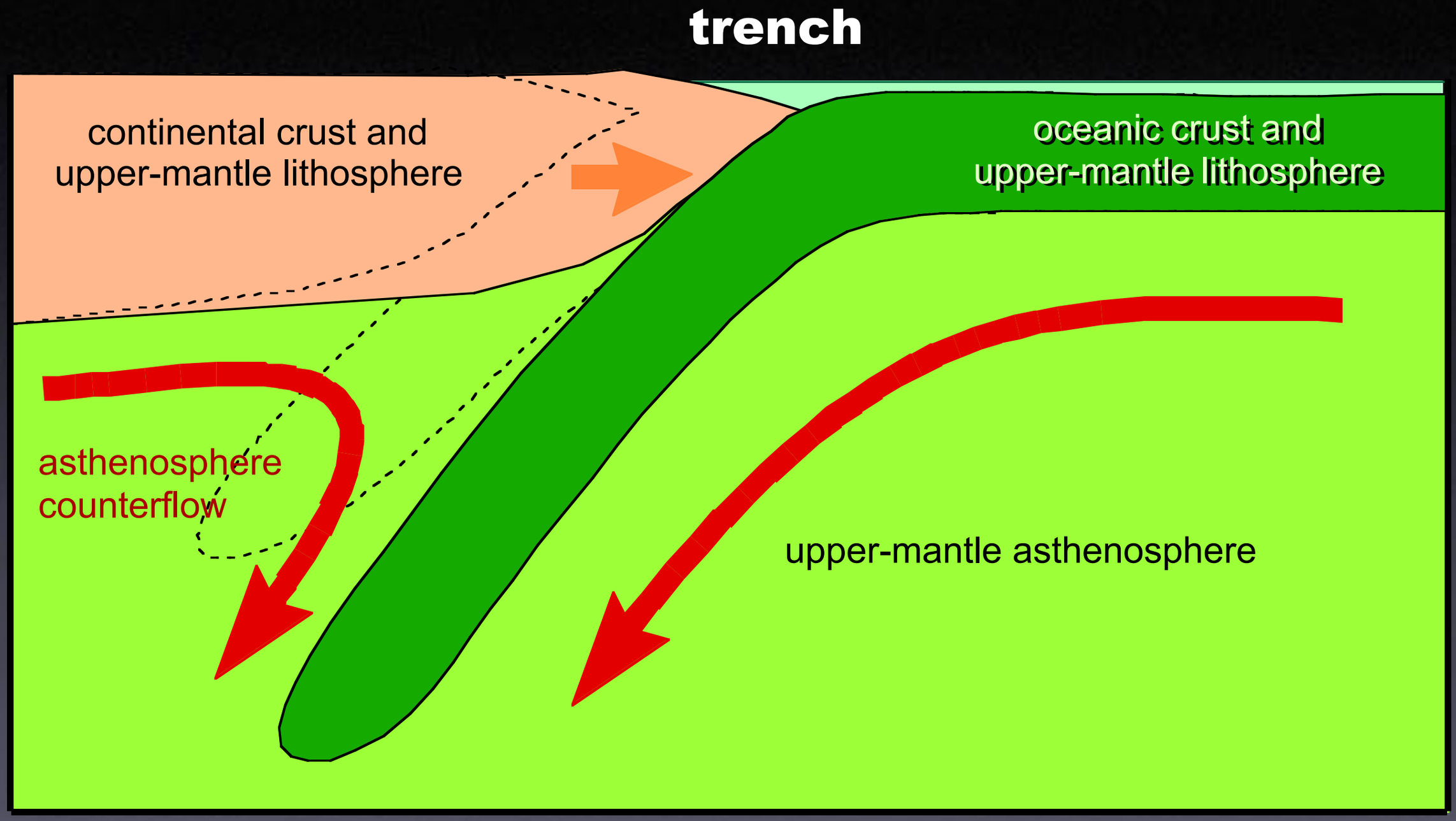

trench
continental crust and
upper-mantle lithosphere
oceanic crust and
upper-mantle lithosphere
upper-mantle asthenosphere

Trench Pull



or Asthenospheric Counterflow

Trench Pull

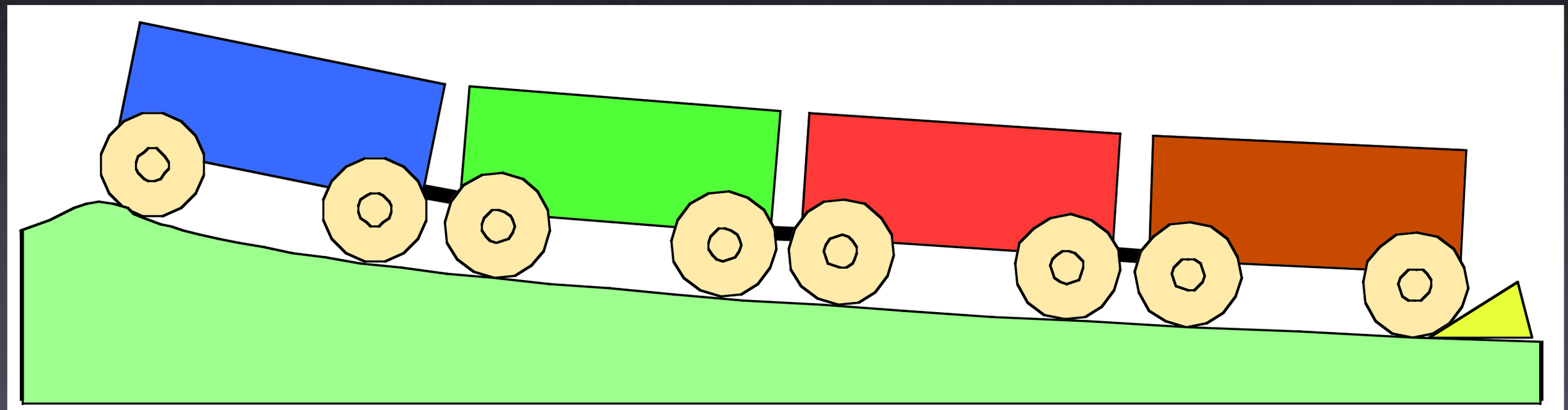


or Asthenospheric Counterflow

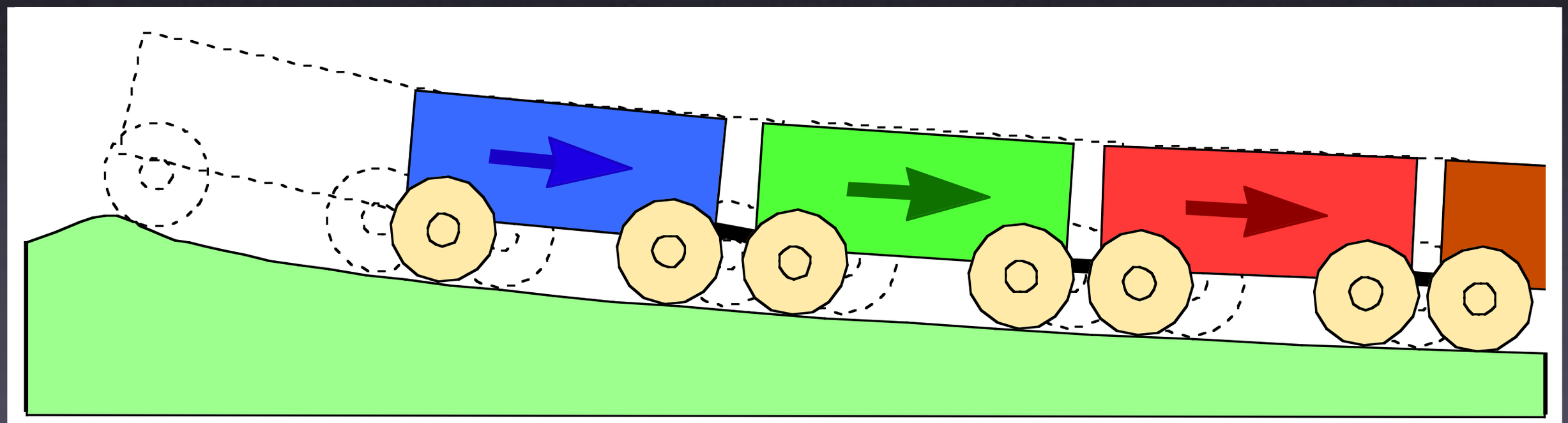
With increasing distance from the axis of the mid-ocean ridge, ...

- the **age** of the lithosphere increases
- the **depth** to the sea floor increases
- the **thickness** of the upper-mantle lithosphere increases due to cooling and accretion from below, so
- **lithosphere thickness** increases

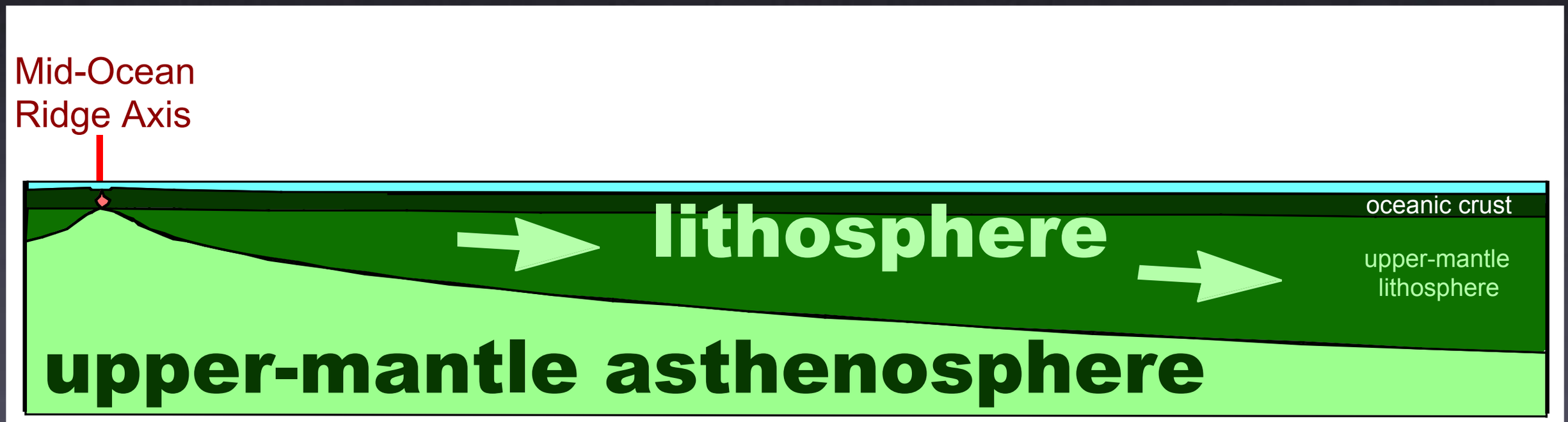
What will happen when the wedge is removed?



Gravity acts on the mass of the train, causing down-slope motion



Gravity acts on the mass of the lithosphere, causing motion away from the ridge



"Ridge push" is really more like "ridge slide"

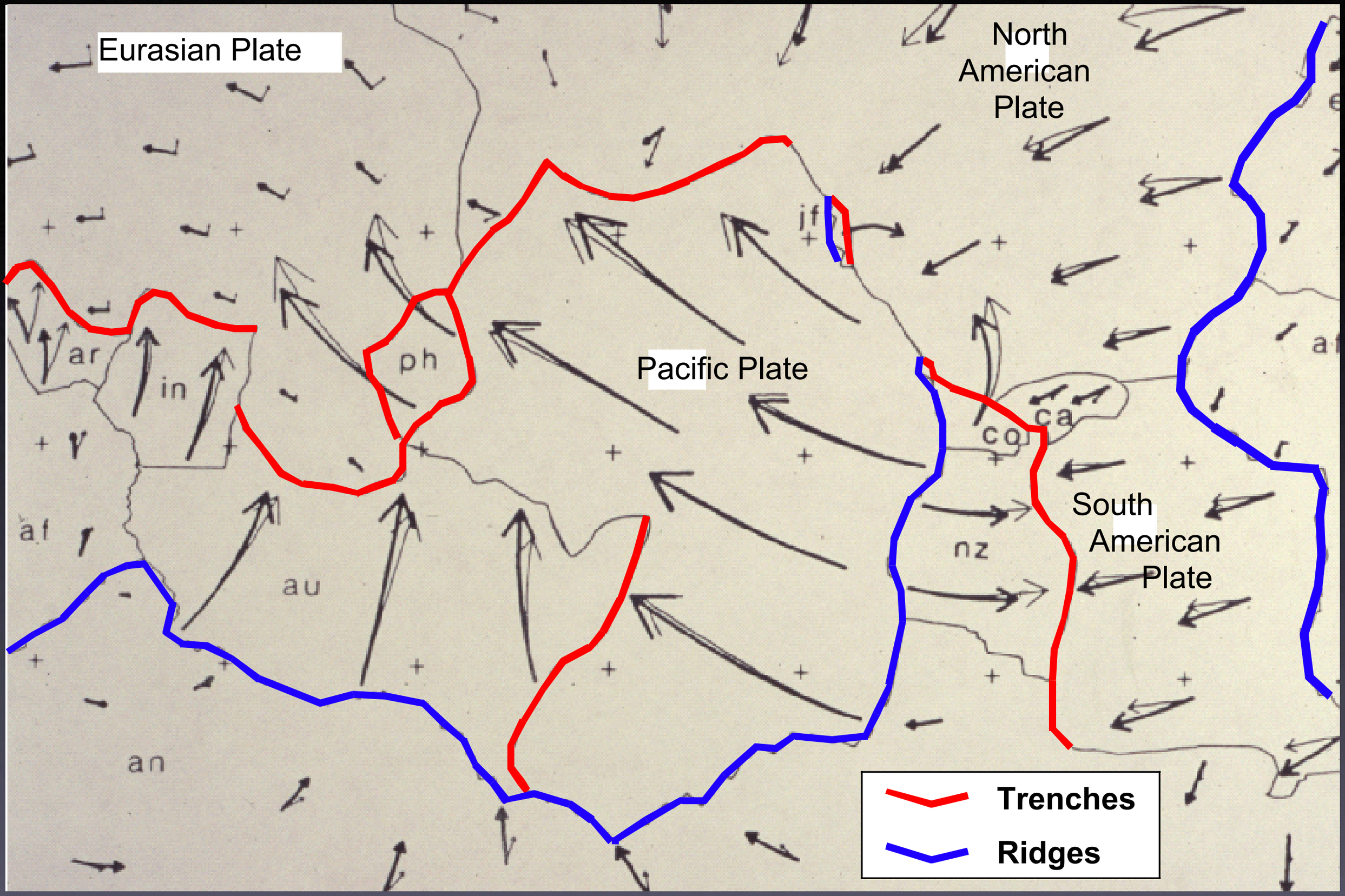
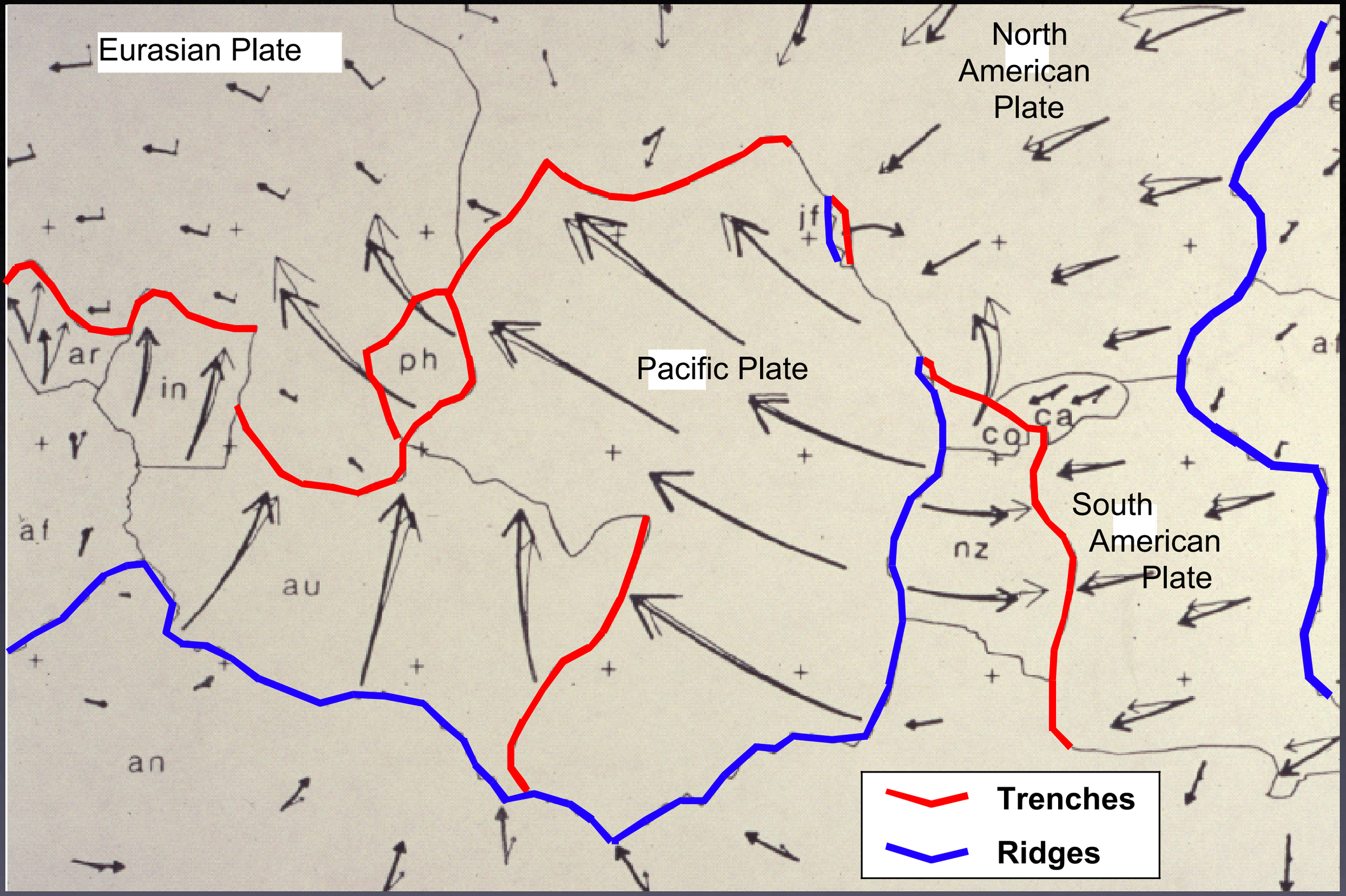


Plate motion relative to the Hawaiian hot spot, from Gripp and Gordon (1992)



Bottom line: The motion of each individual plate is a combination of motion toward a subducting edge, away from a spreading ridge, or toward a trench.

Why do plates move?

- **Slab pull** (most important)
- **Ridge push** (important)
- **Trench pull** or asthenosphere counterflow (locally important)
- **Convection**: viscous drag by a convecting mantle (?)
- Eötvös force, et cetera