

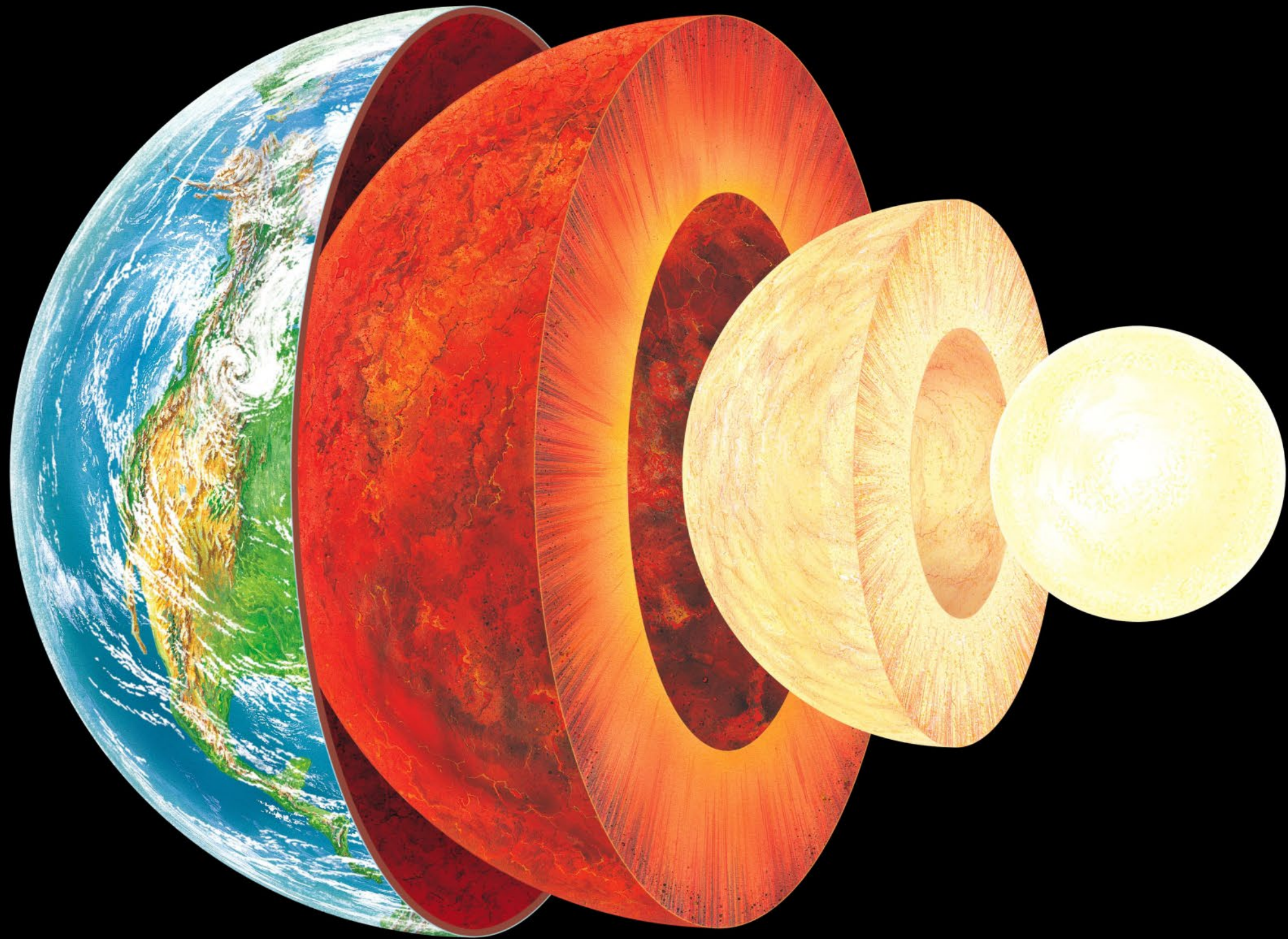


Earth's Interior

Goal: Students will be able to describe the different components of Earth's Interior, by using the "Inferred Properties of Earth's Interior" chart in the ESRT.

What is inside Earth?

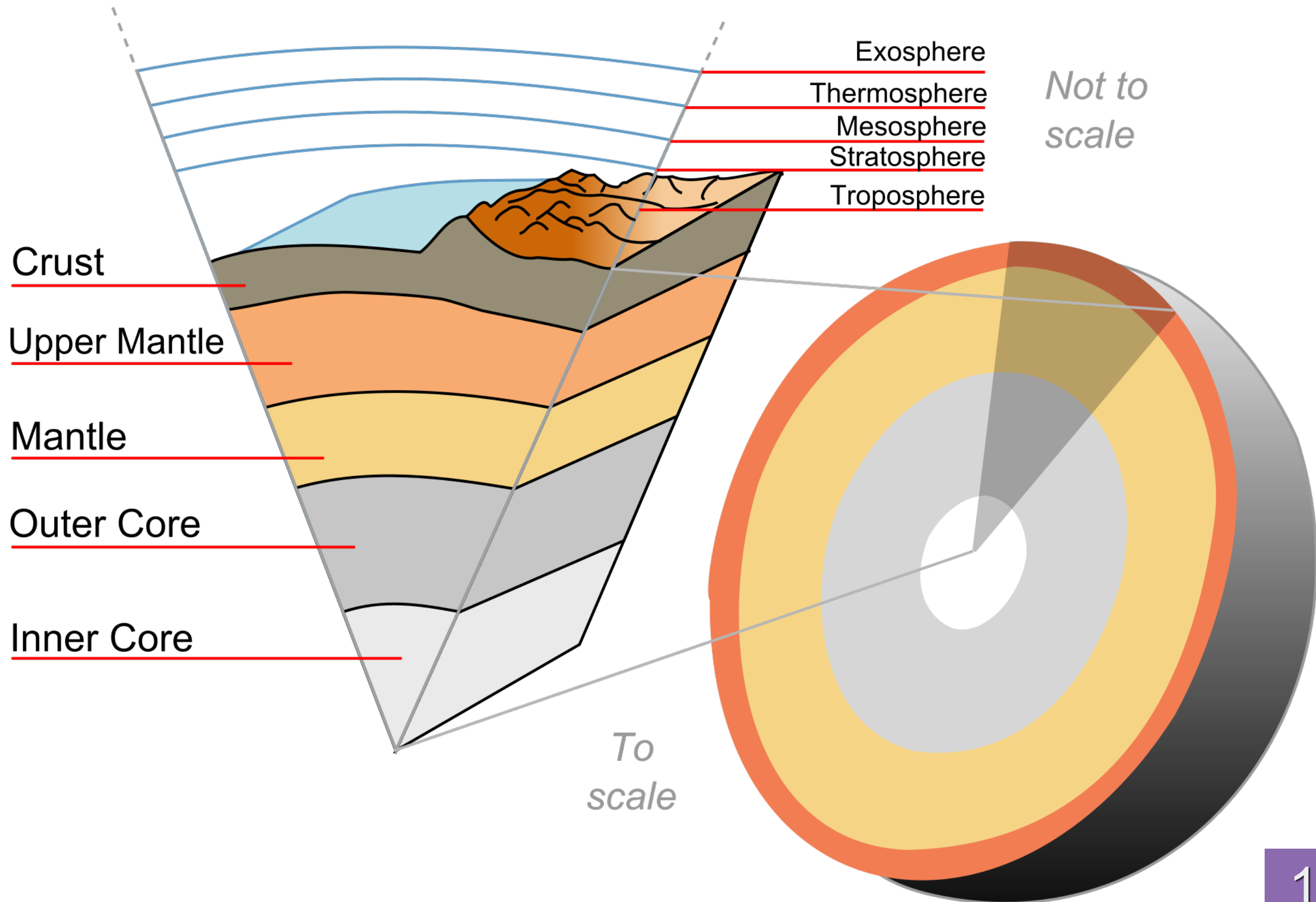
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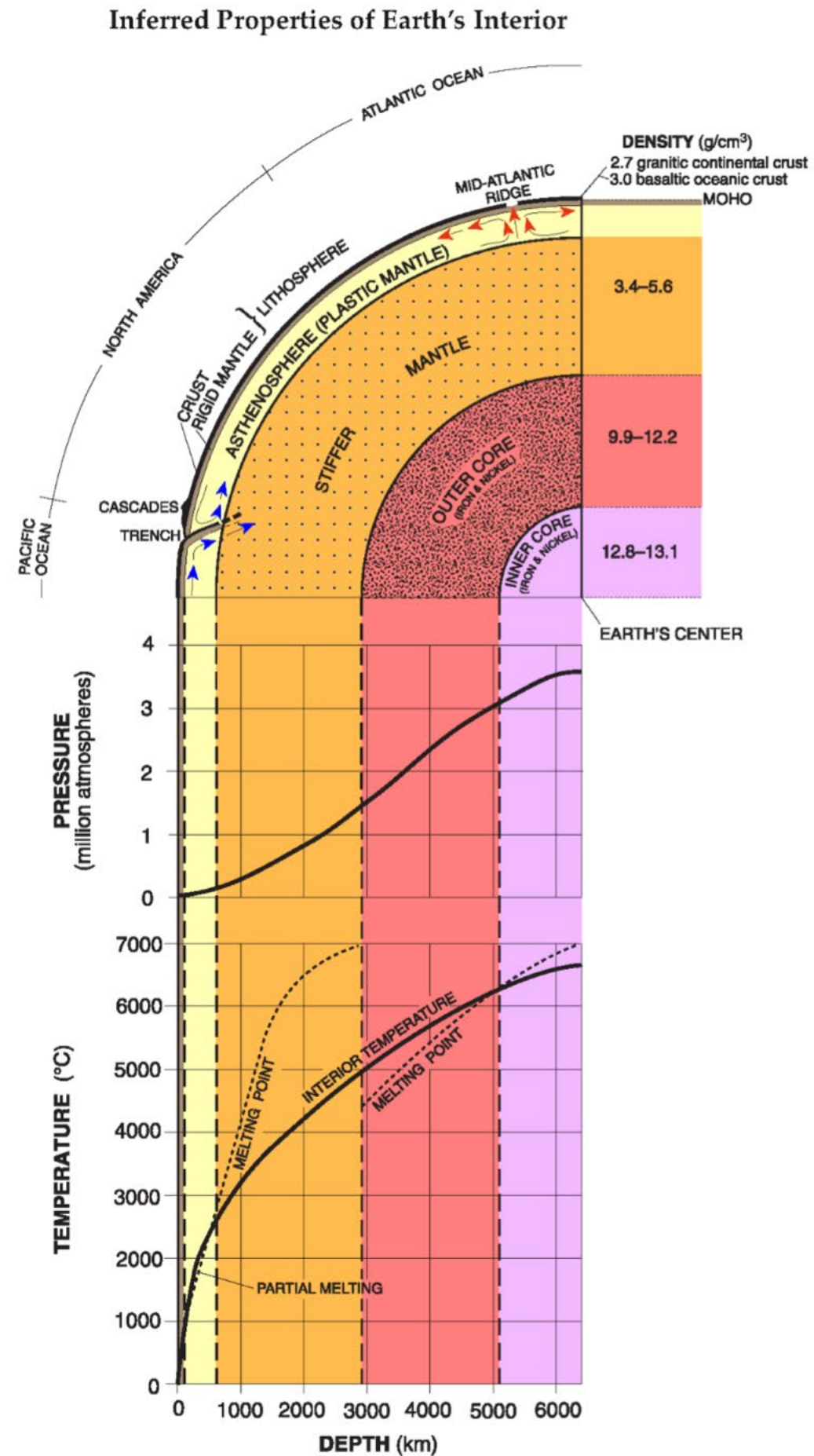
How do we know what is inside Earth?

- By observing **earthquake waves** and the way they travel through the planet, scientists make **inferences** about **Earth's structure**.

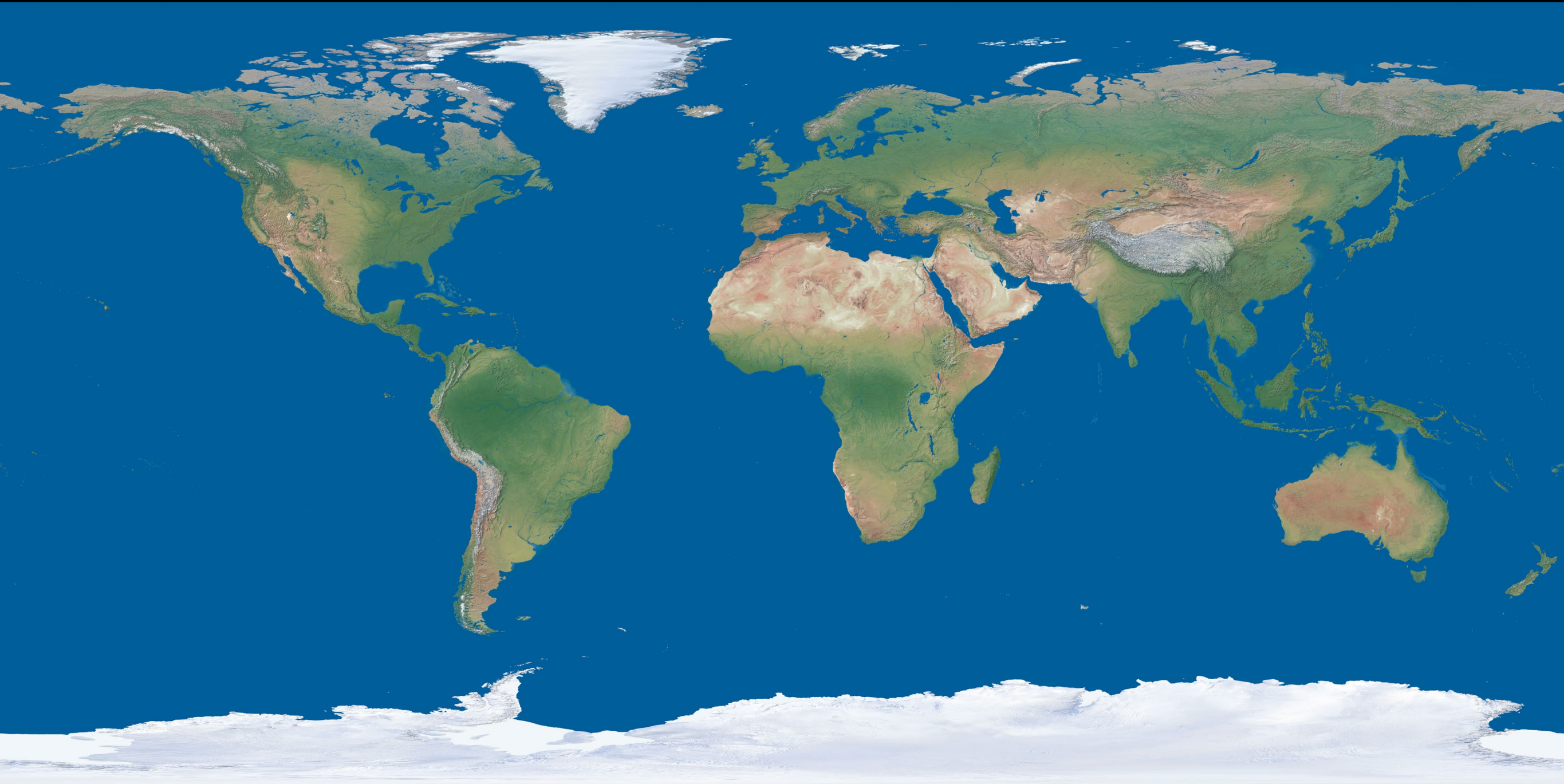
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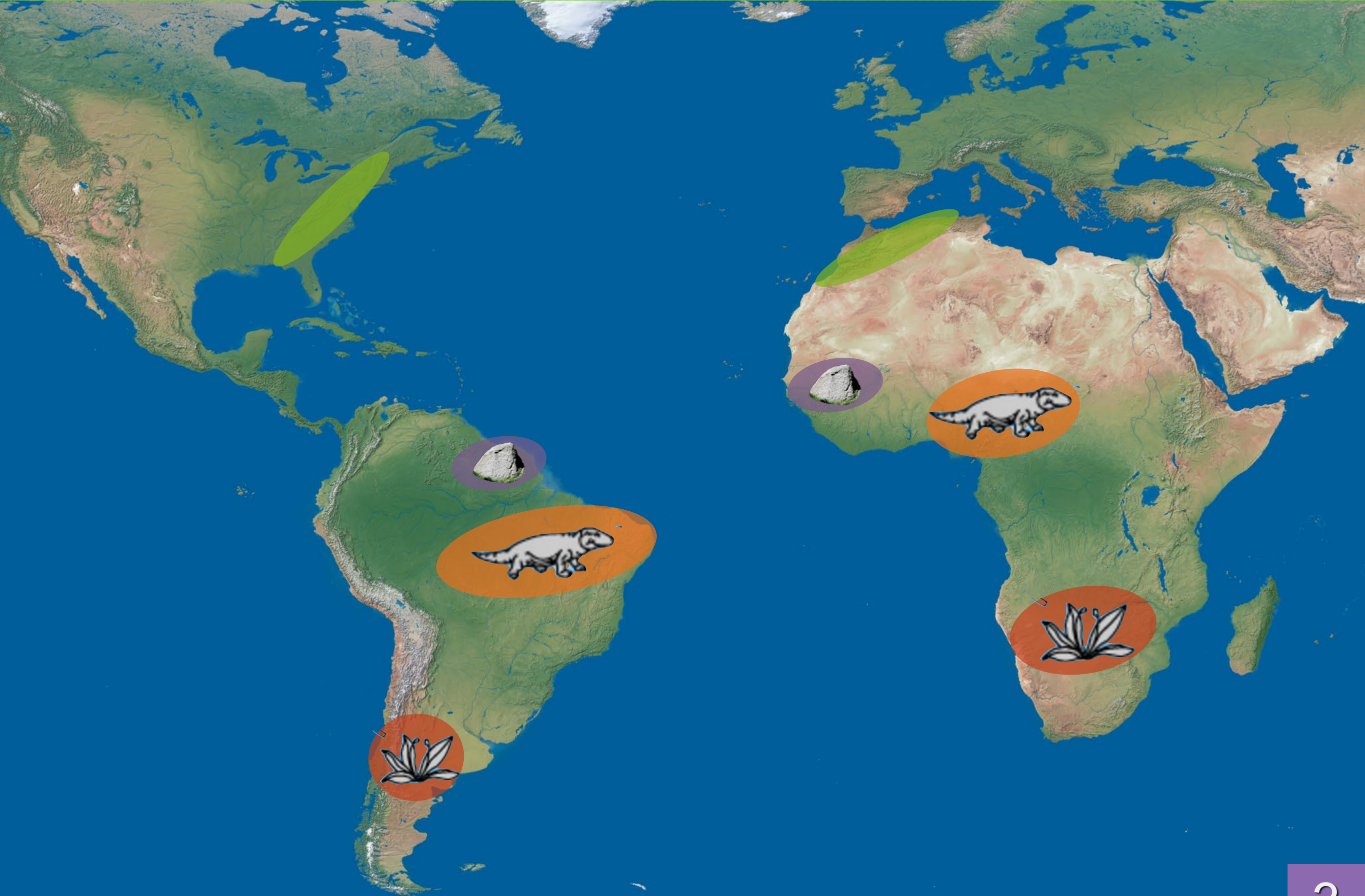
Goal: Students will be able to describe the different components of Earth's Interior, by using the "Inferred Properties of Earth's Interior" chart in the ESRT.



Goal: Students will look at the fossil and rock record found throughout Earth, and be able to explain the implications of their locations. Students will explain why this occurred.



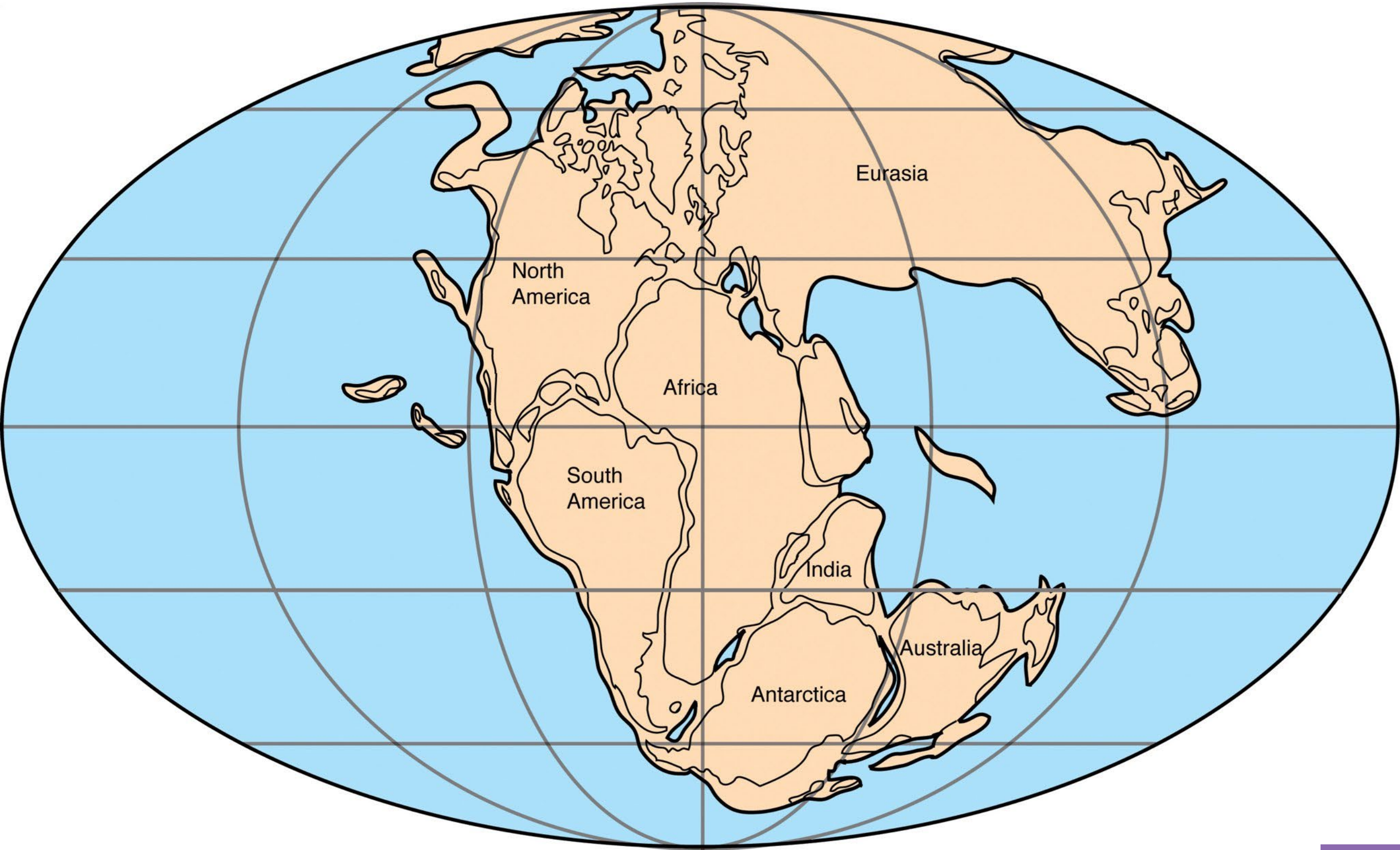
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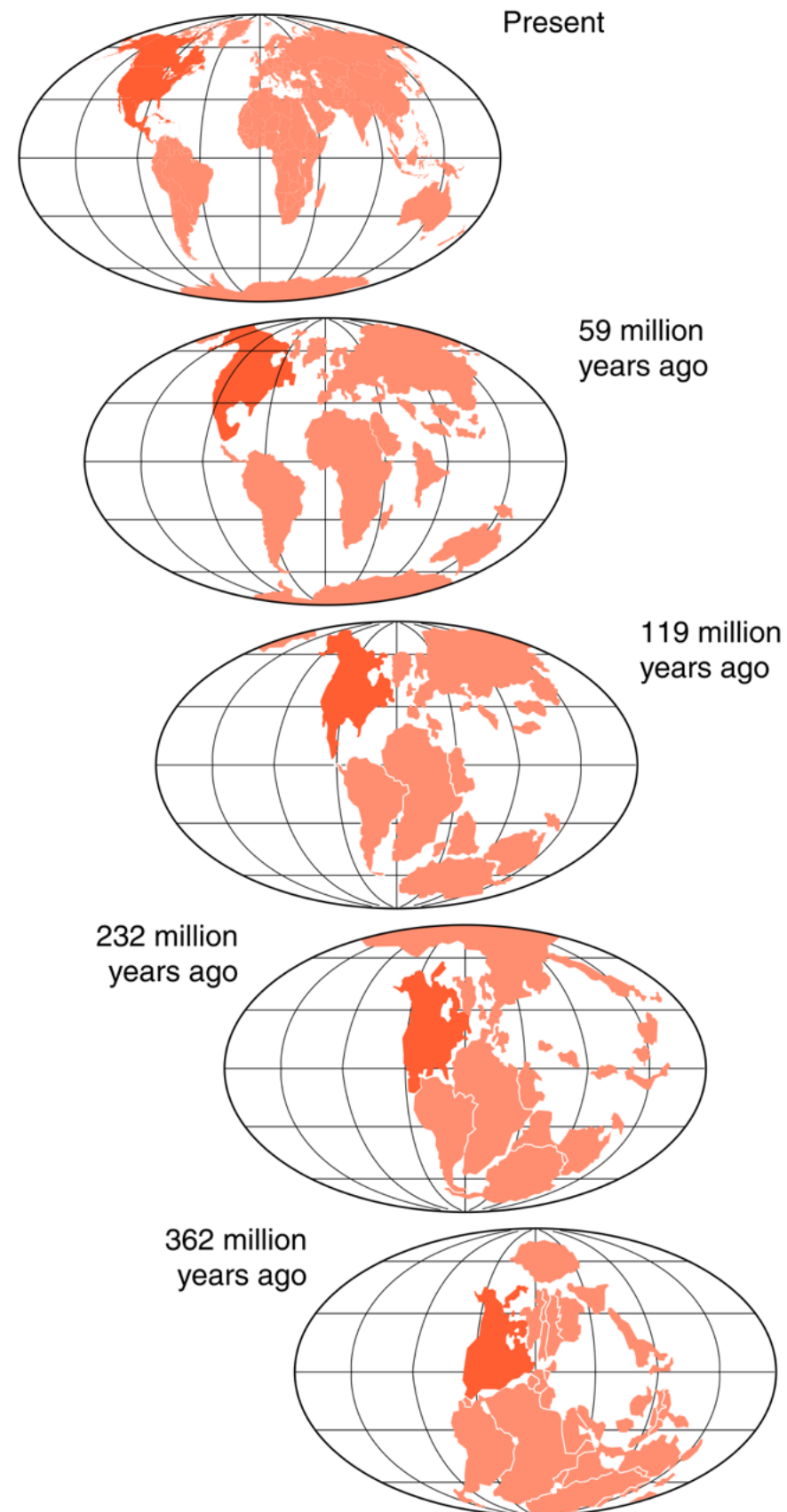
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Earth is not a completely solid planet, which means it is capable of constantly changing.

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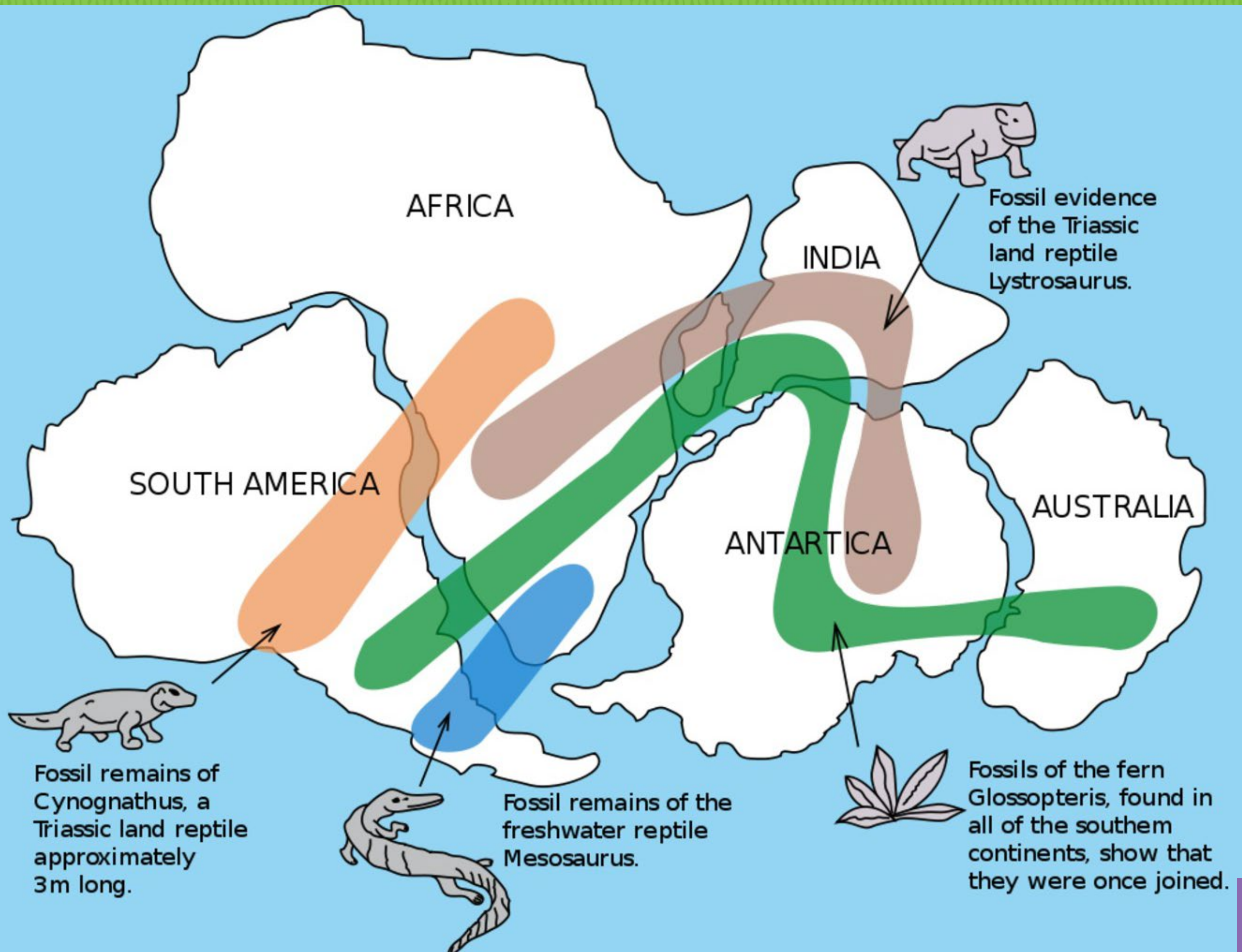
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Evidence For Continental Drift

- Fossil evidence.

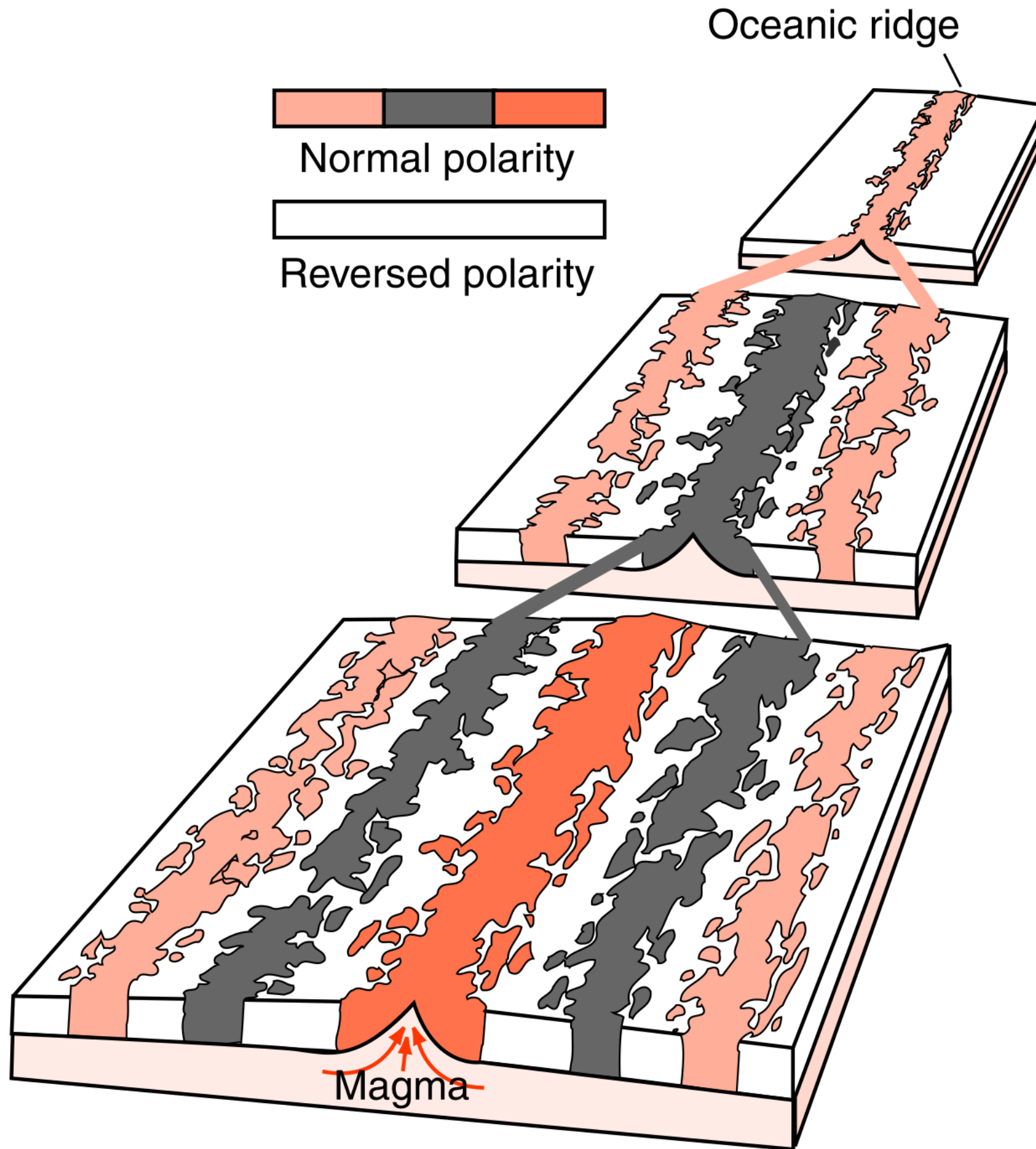
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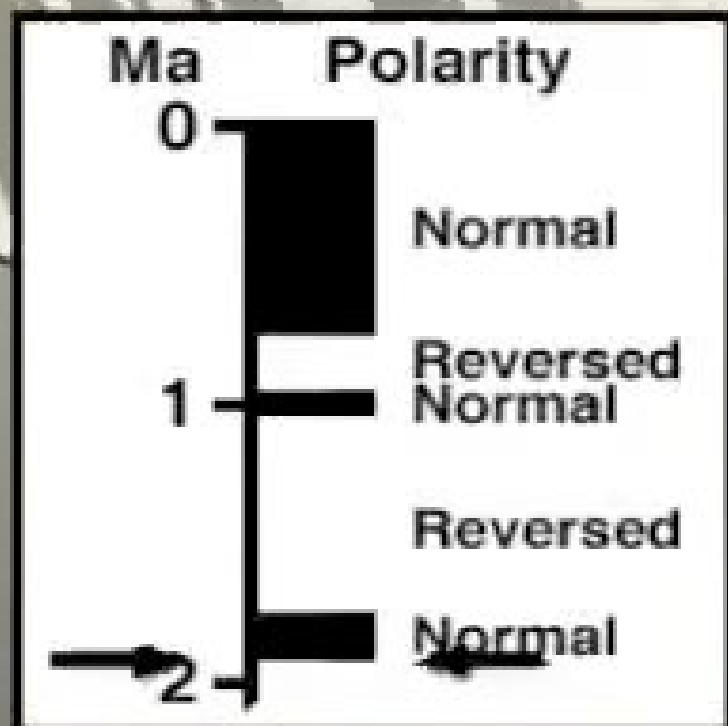


Evidence For Continental Drift

- Fossil evidence.
- Polarity of sea floor rocks.

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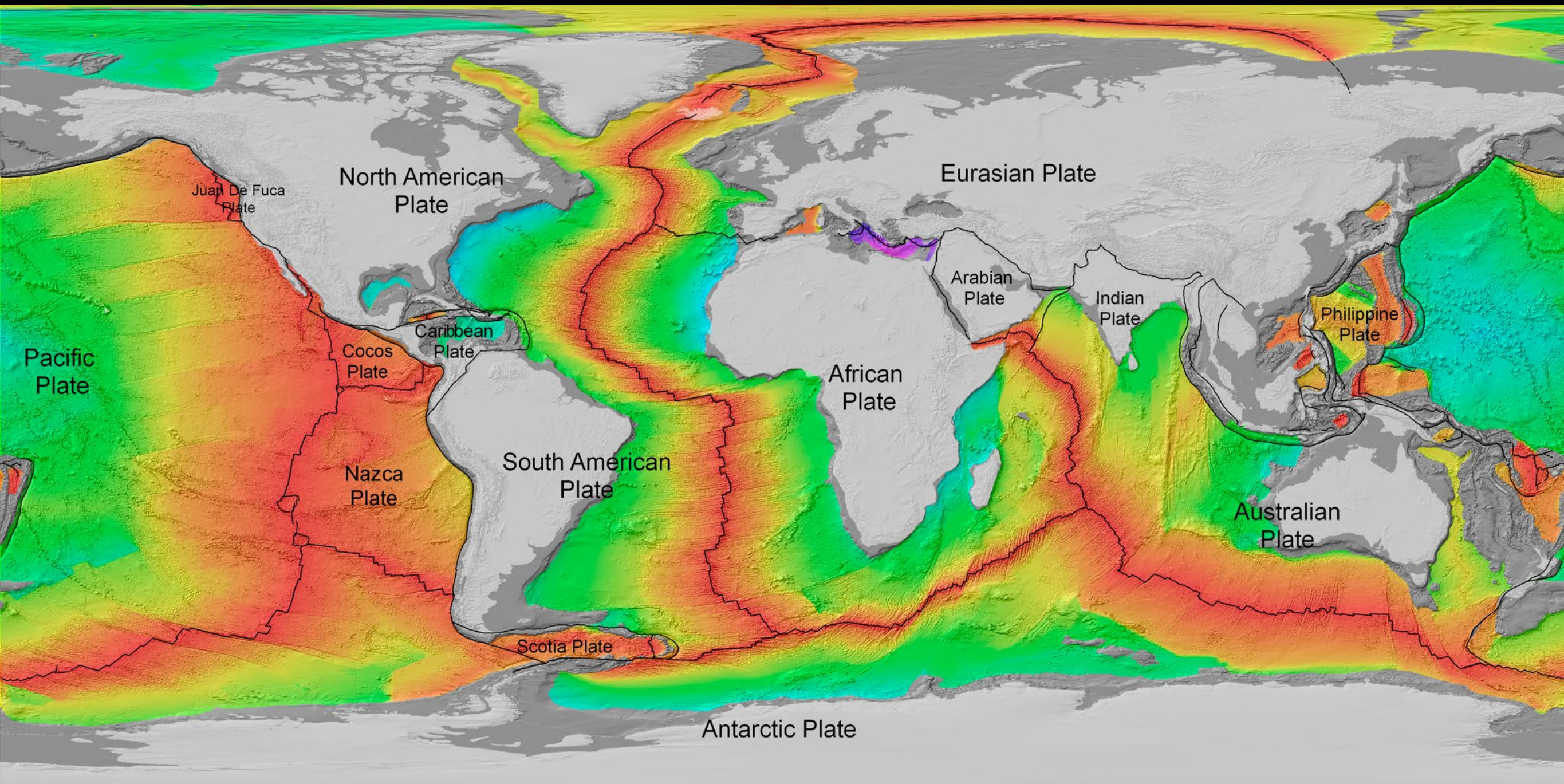




Evidence For Continental Drift

- Fossil evidence.
- Polarity of sea floor rocks.
- Age of rocks along plates.

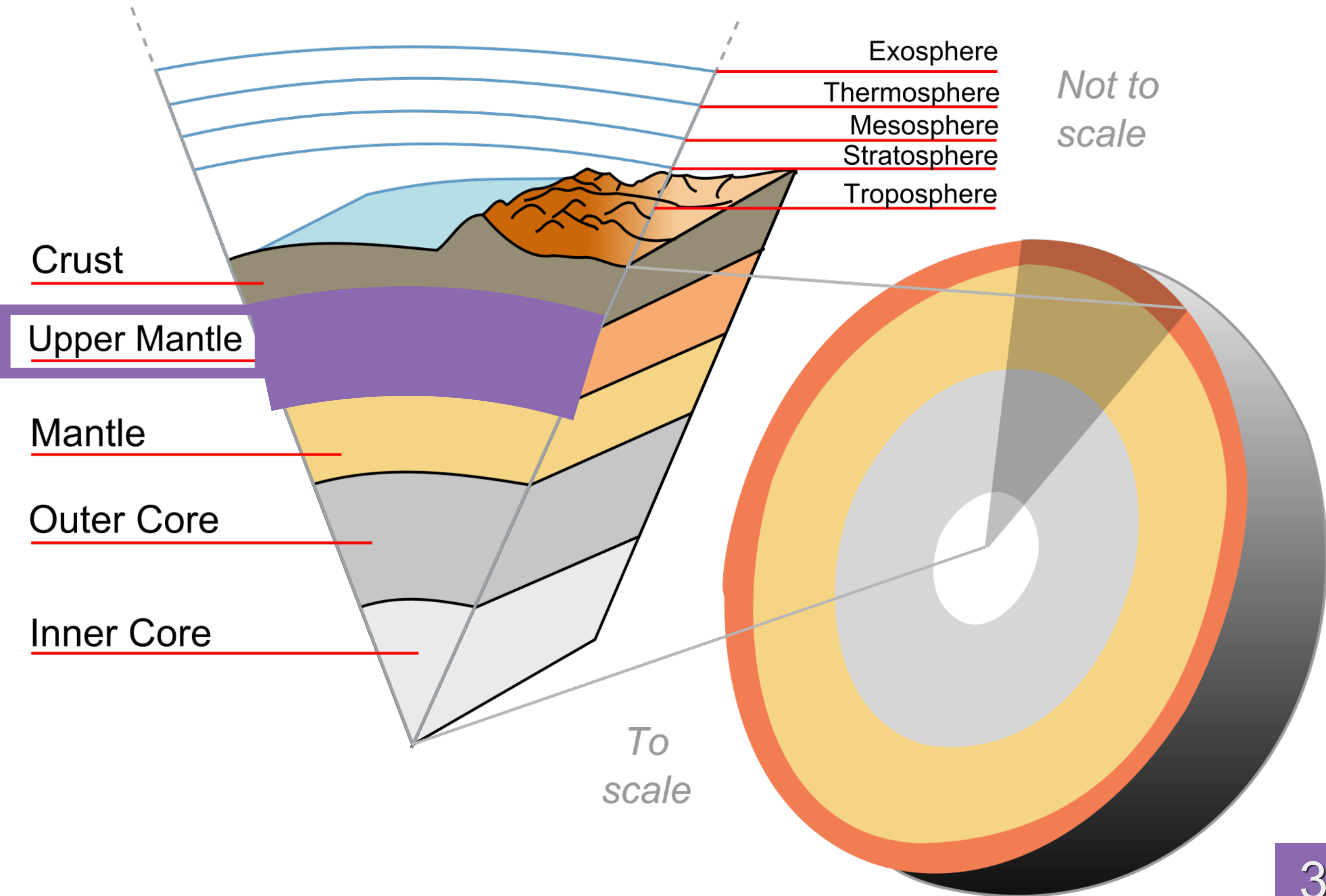
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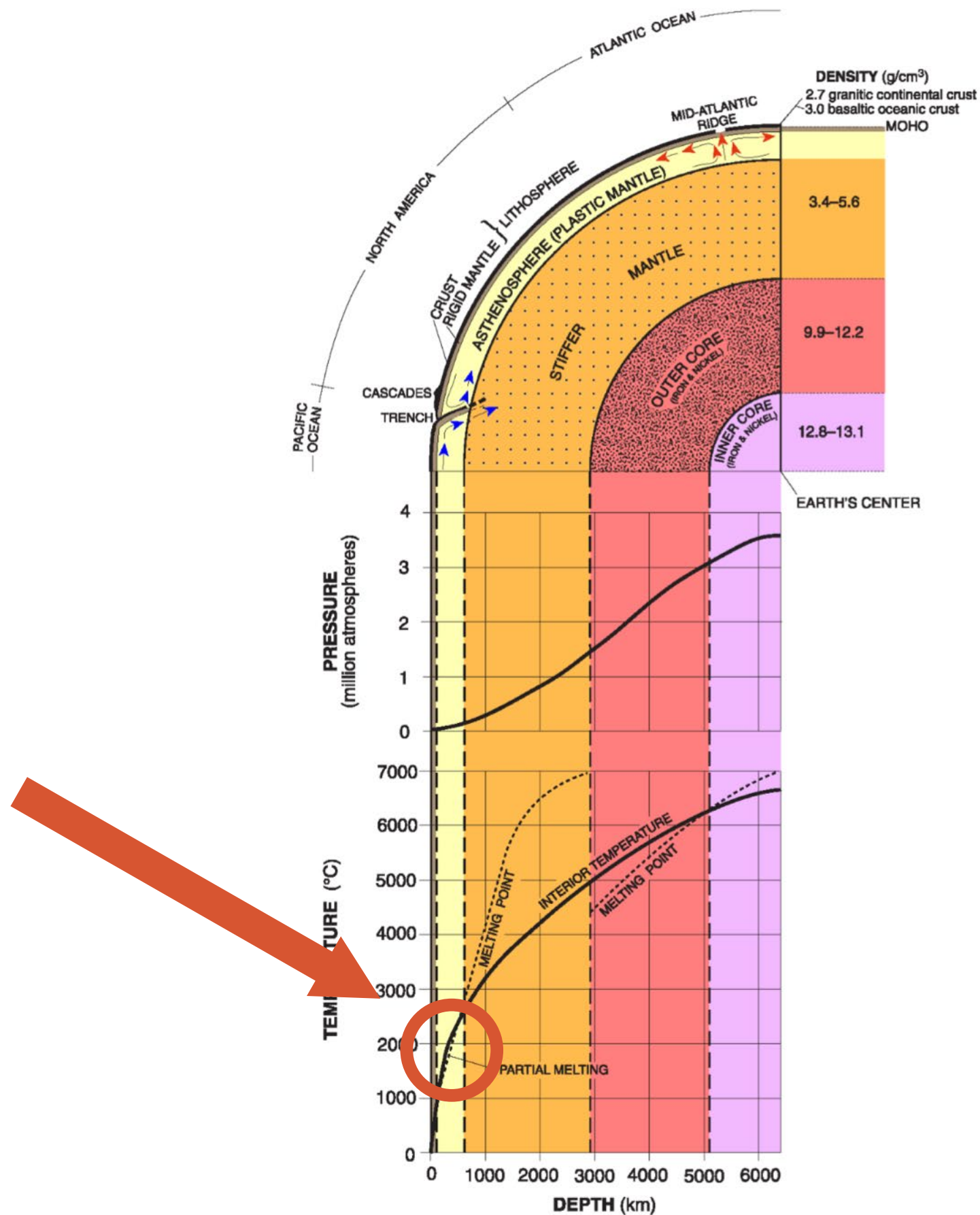
Why do continents move?

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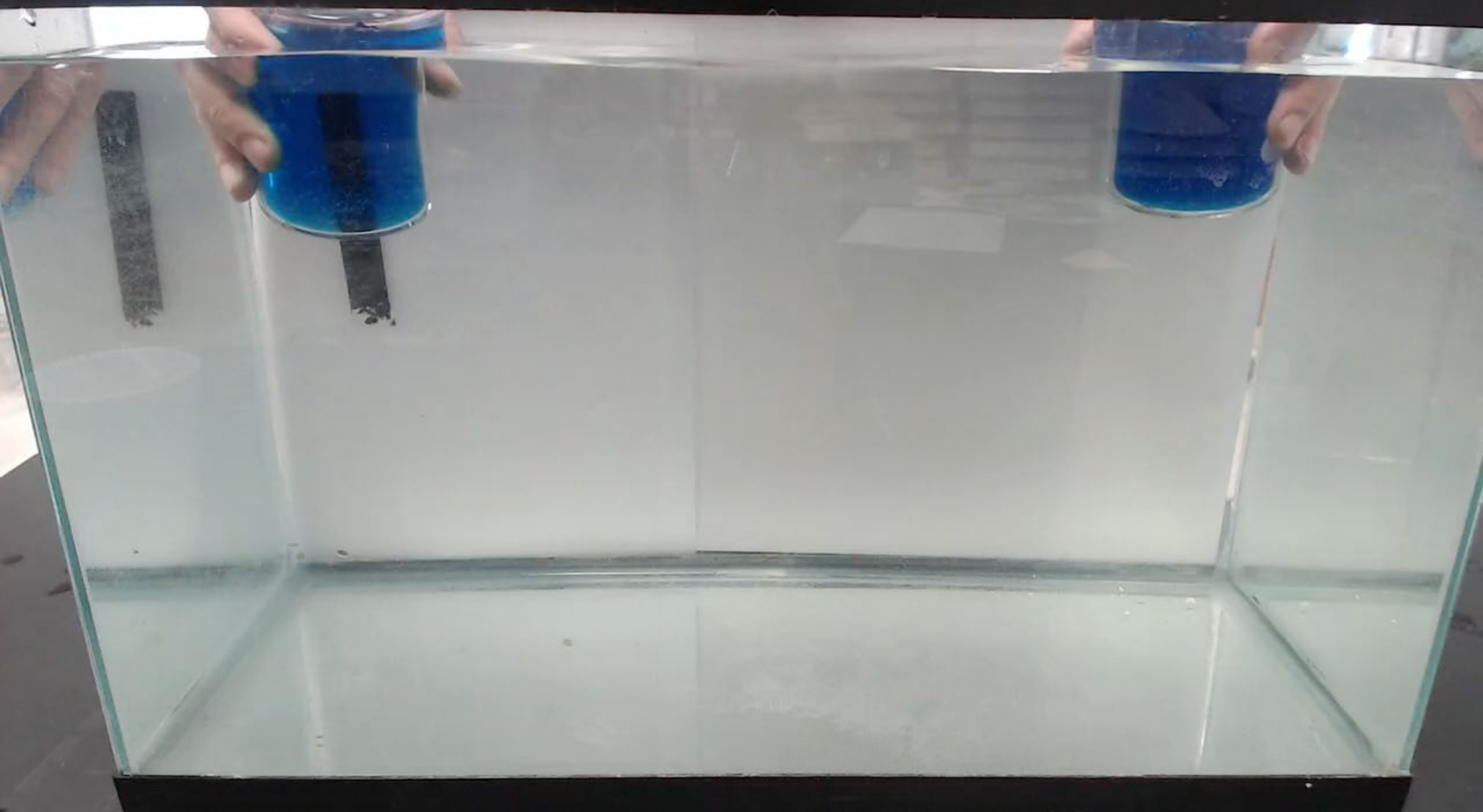


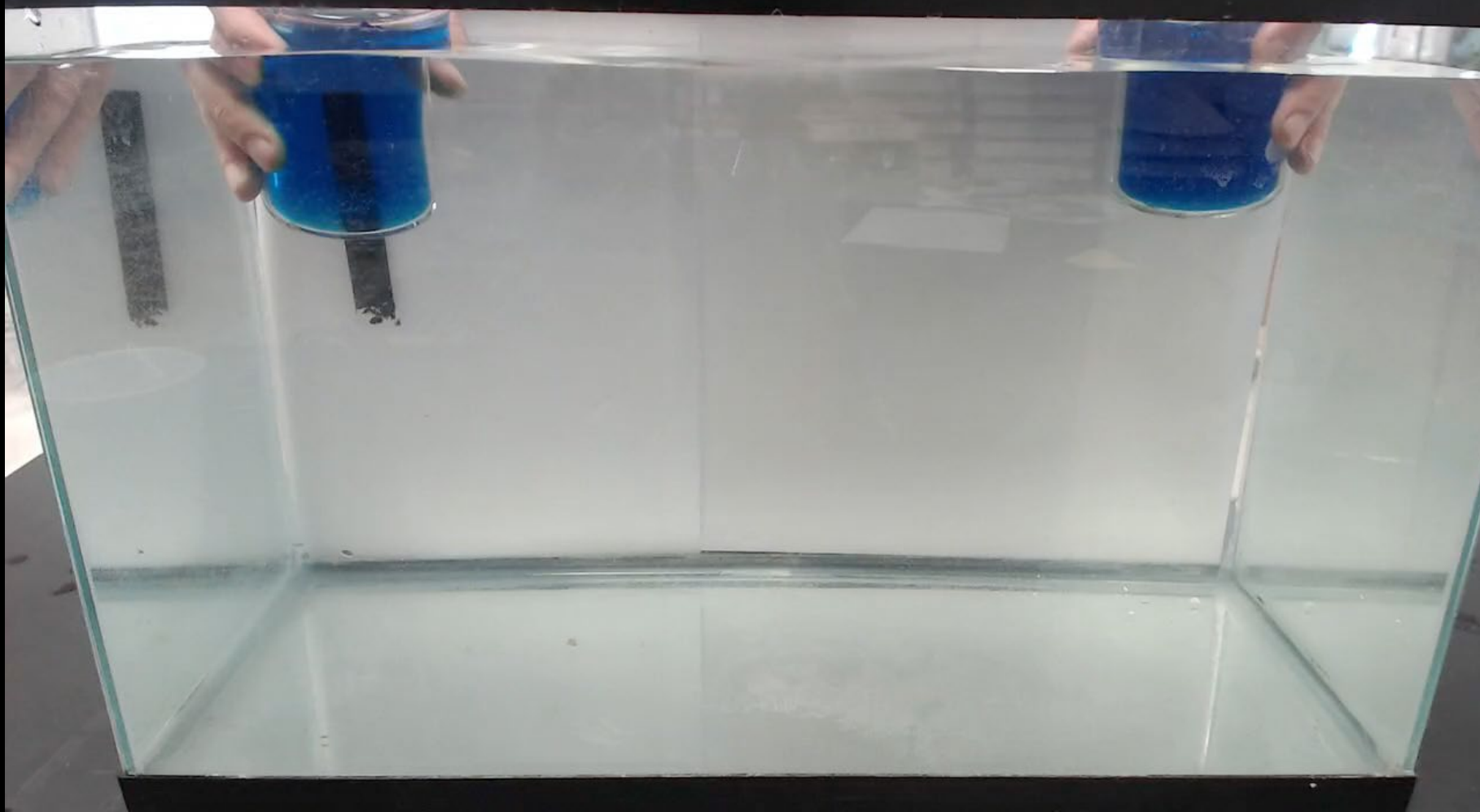
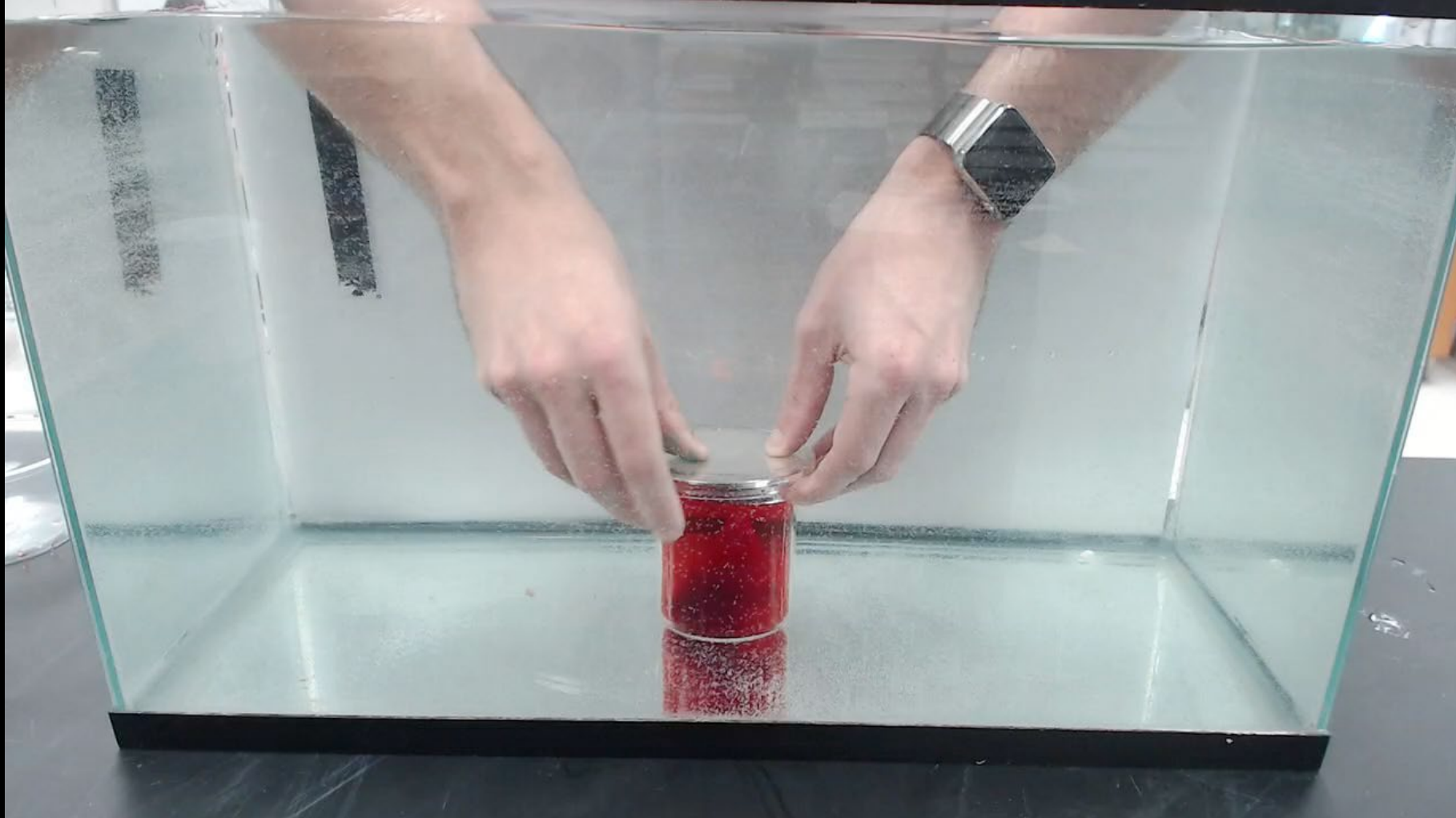
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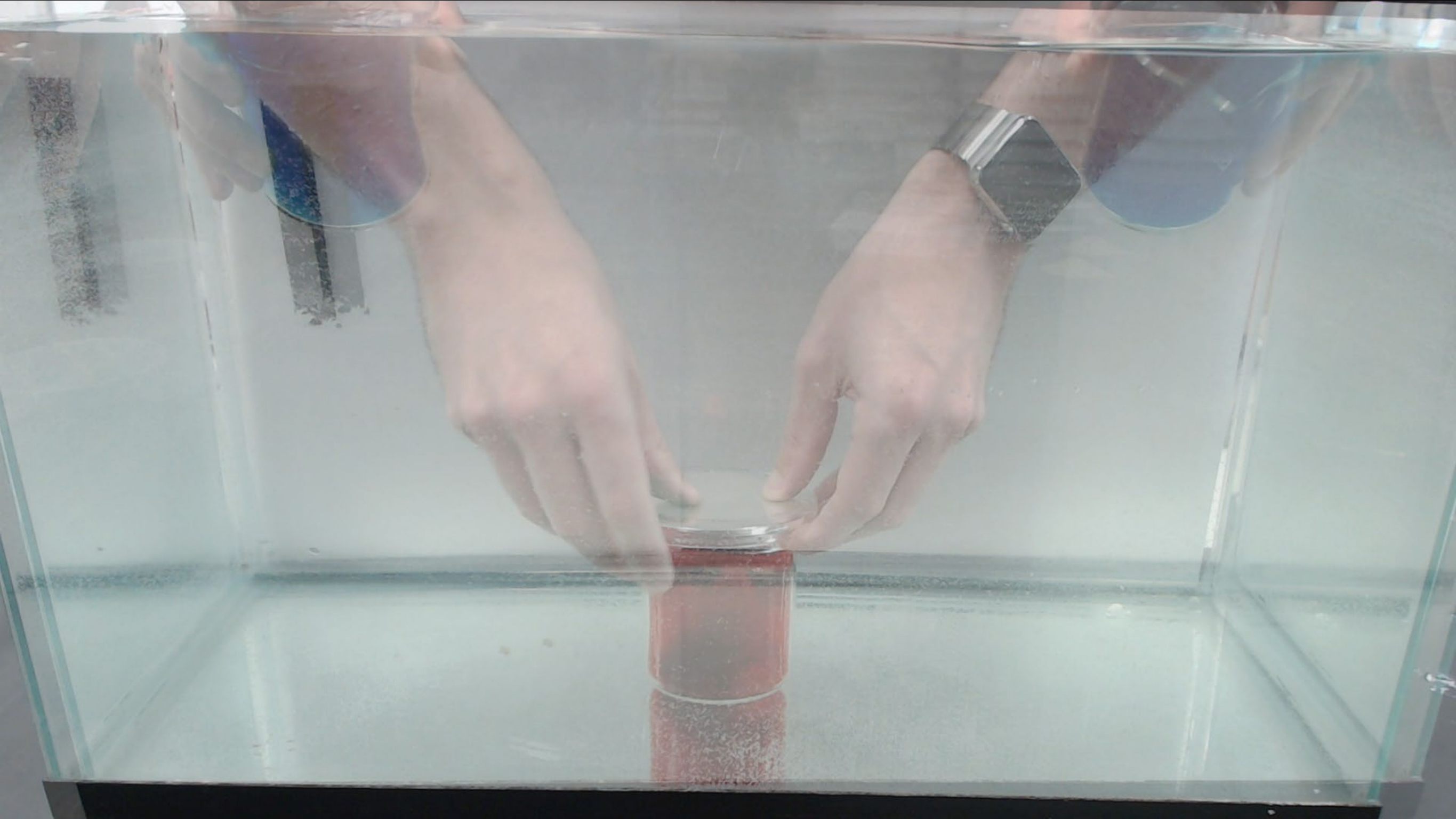
Inferred Properties of Earth's Interior

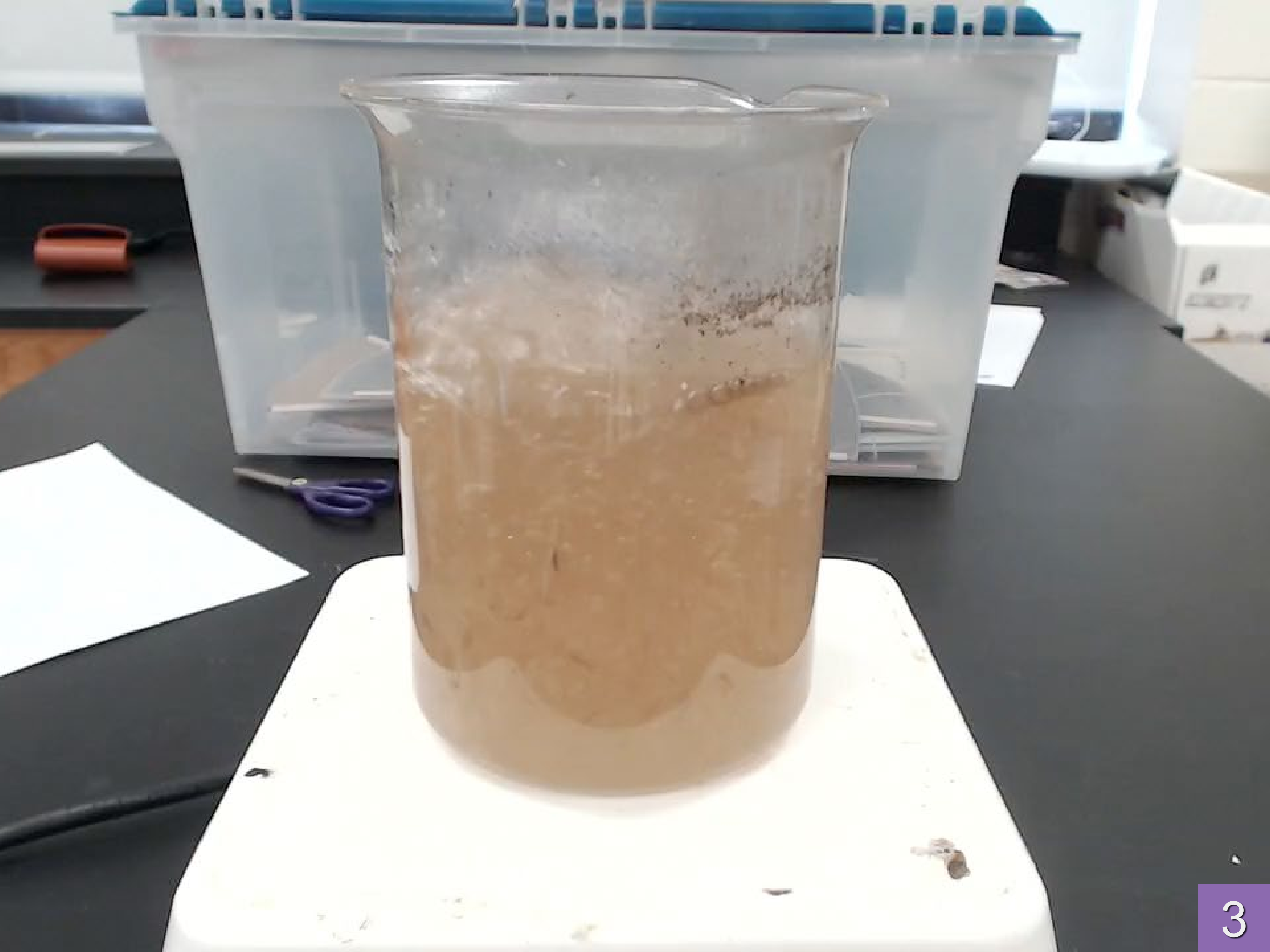




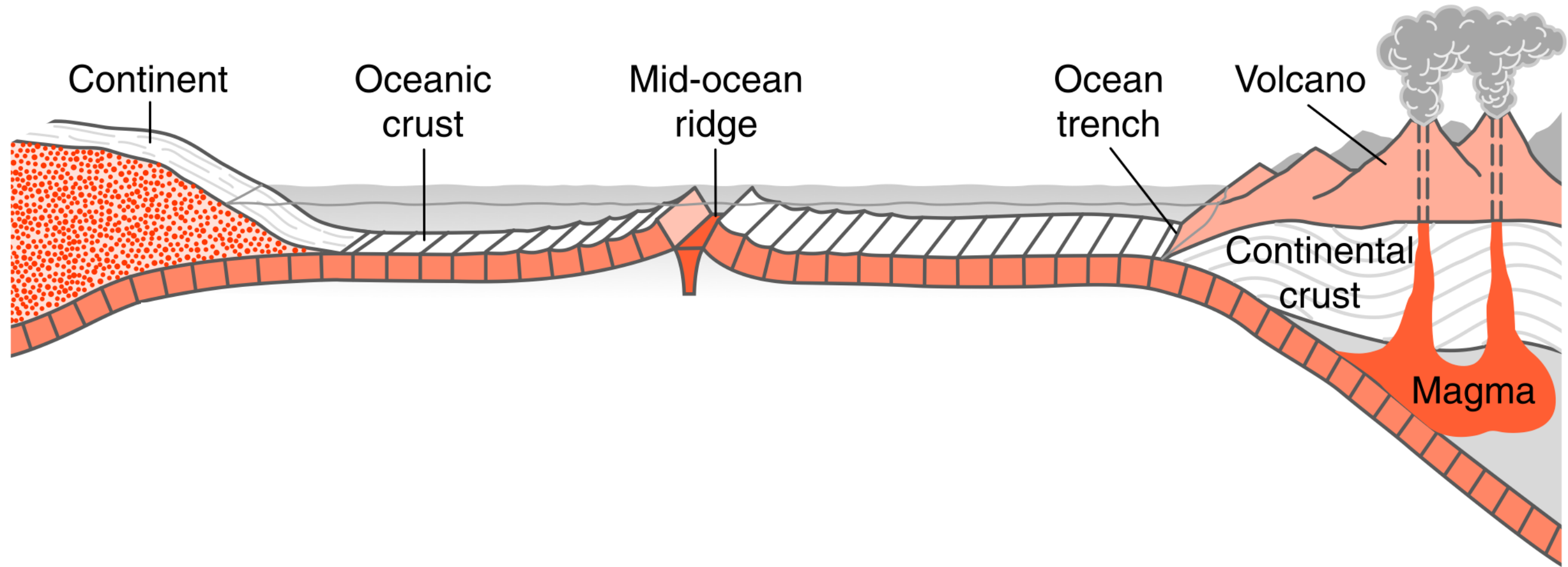




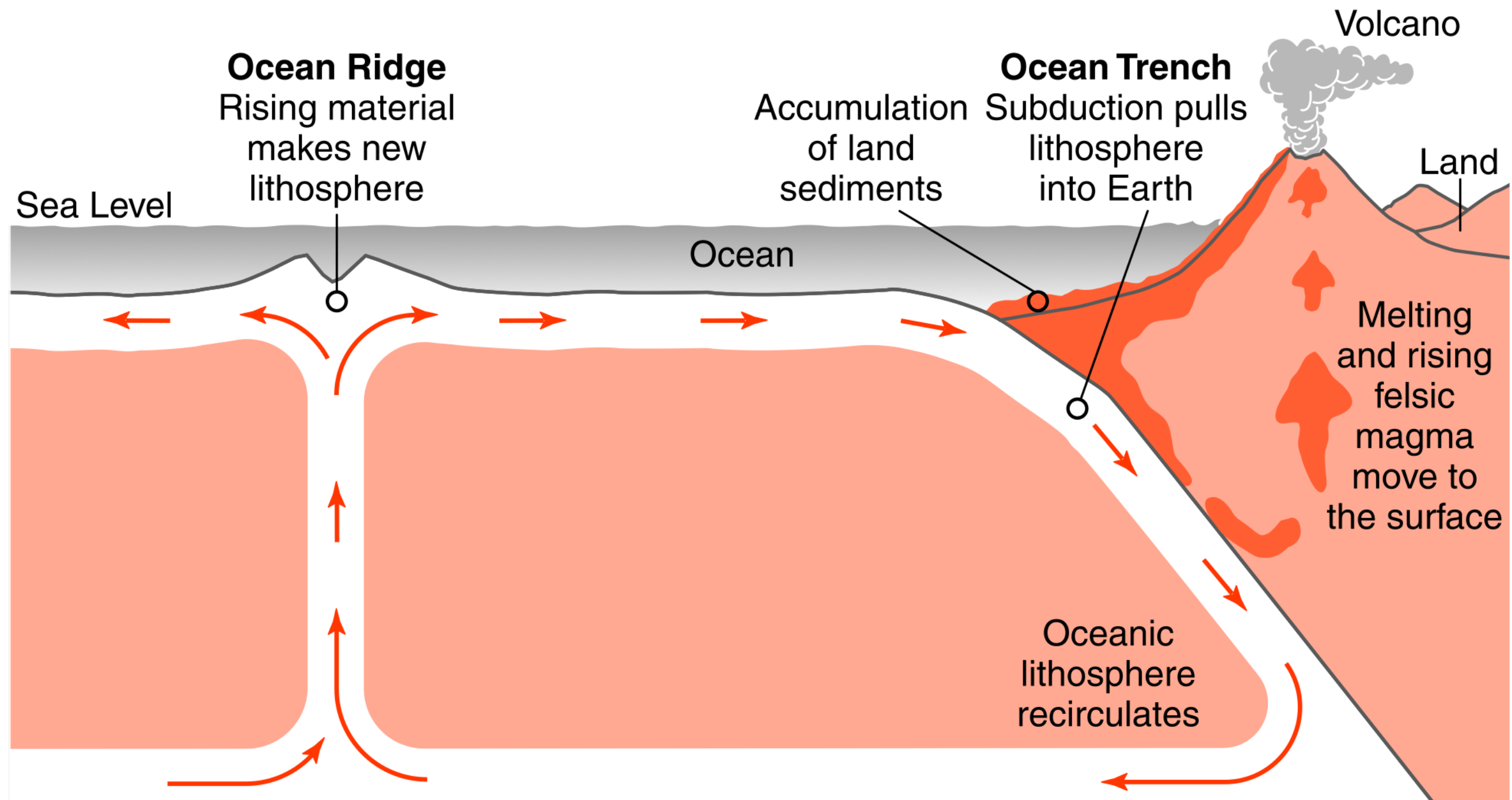




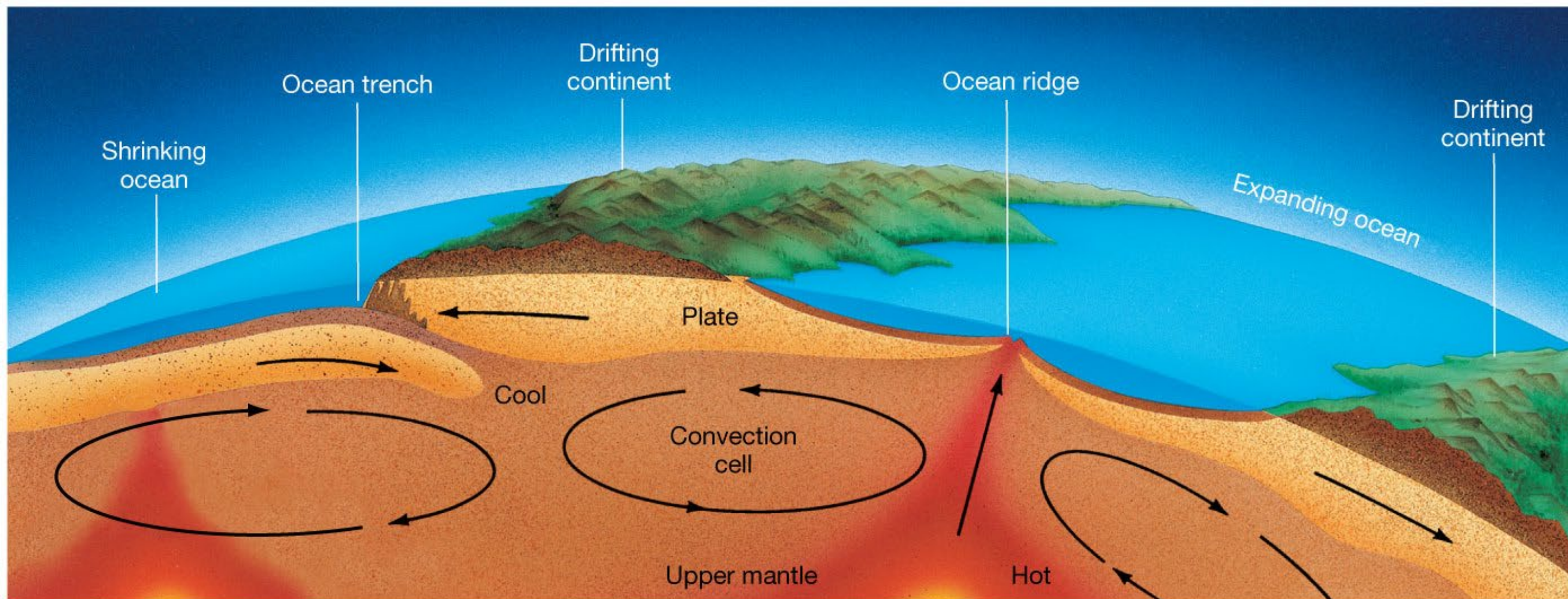
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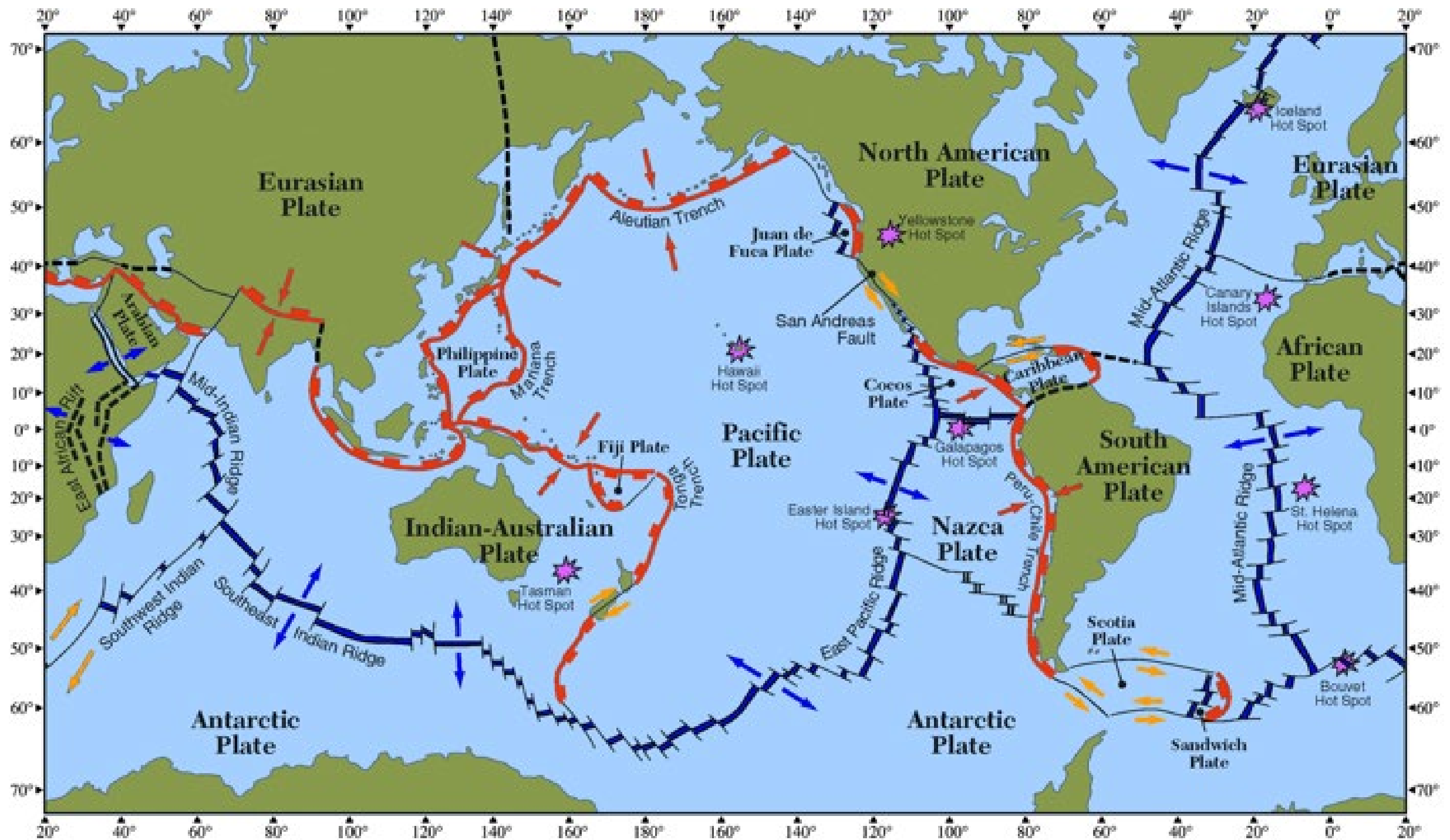


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Goal: Students will be able to describe the types of plate boundaries that can exist.

Tectonic Plates



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
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Complex or uncertain
plate boundary

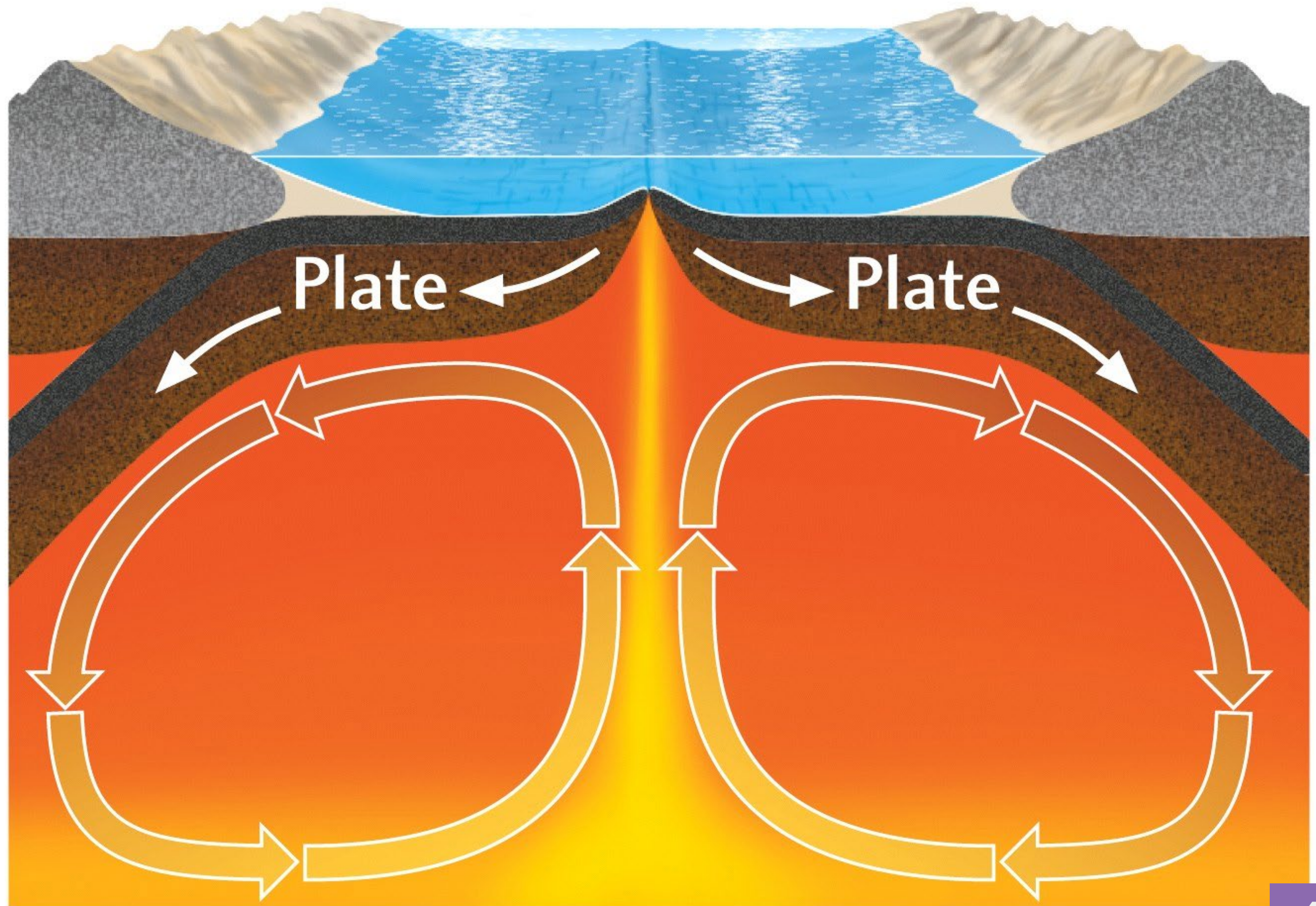
★
Mantle
hot spot

NOTE: Not all mantle hot spots, plates, and boundaries are shown.

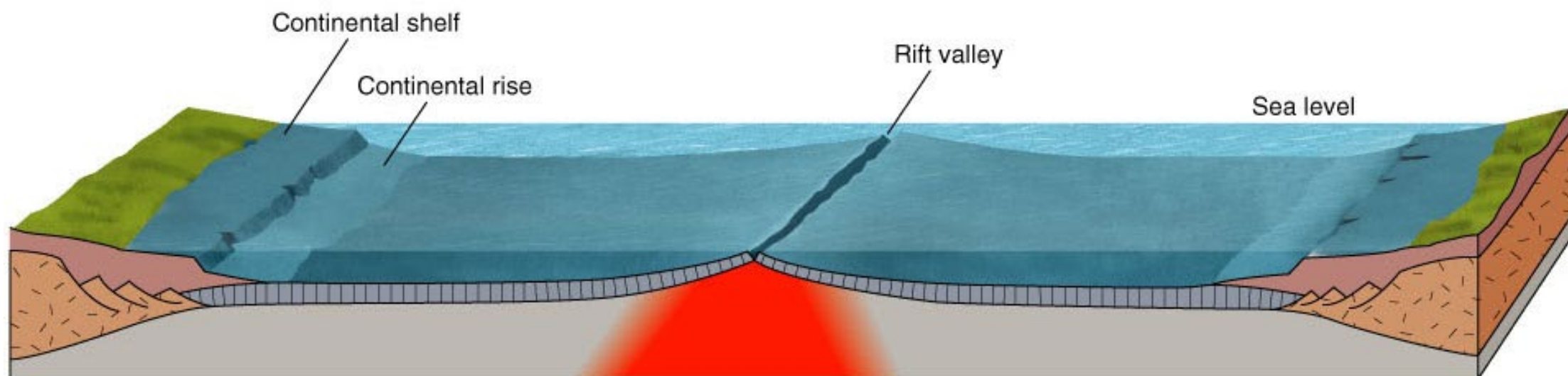
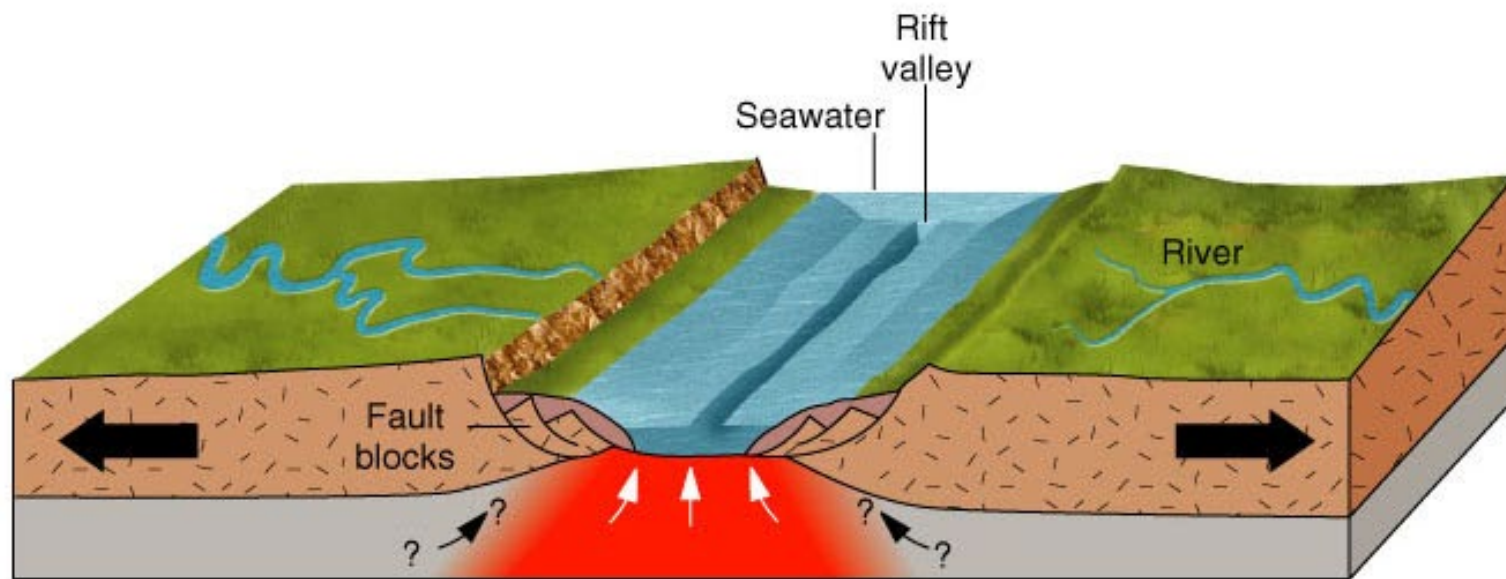
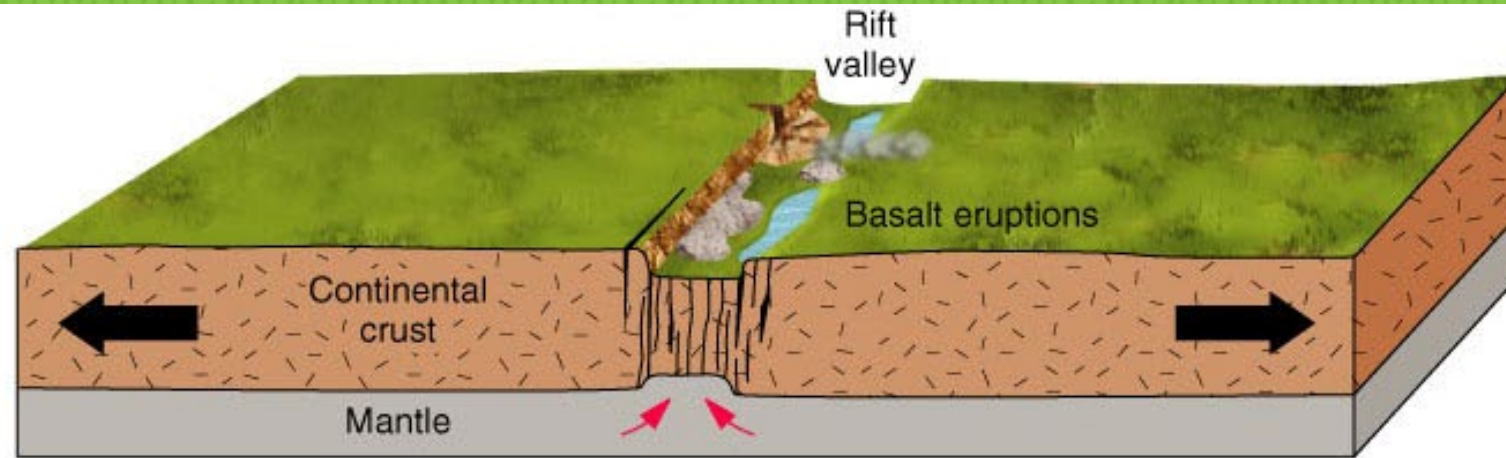
Plate Boundaries

- **Divergent** - area where two plates **move apart**.
- **Convergent** - area where two plates **move together**.
- **Transform** - area where two plates **slide alongside each other**.

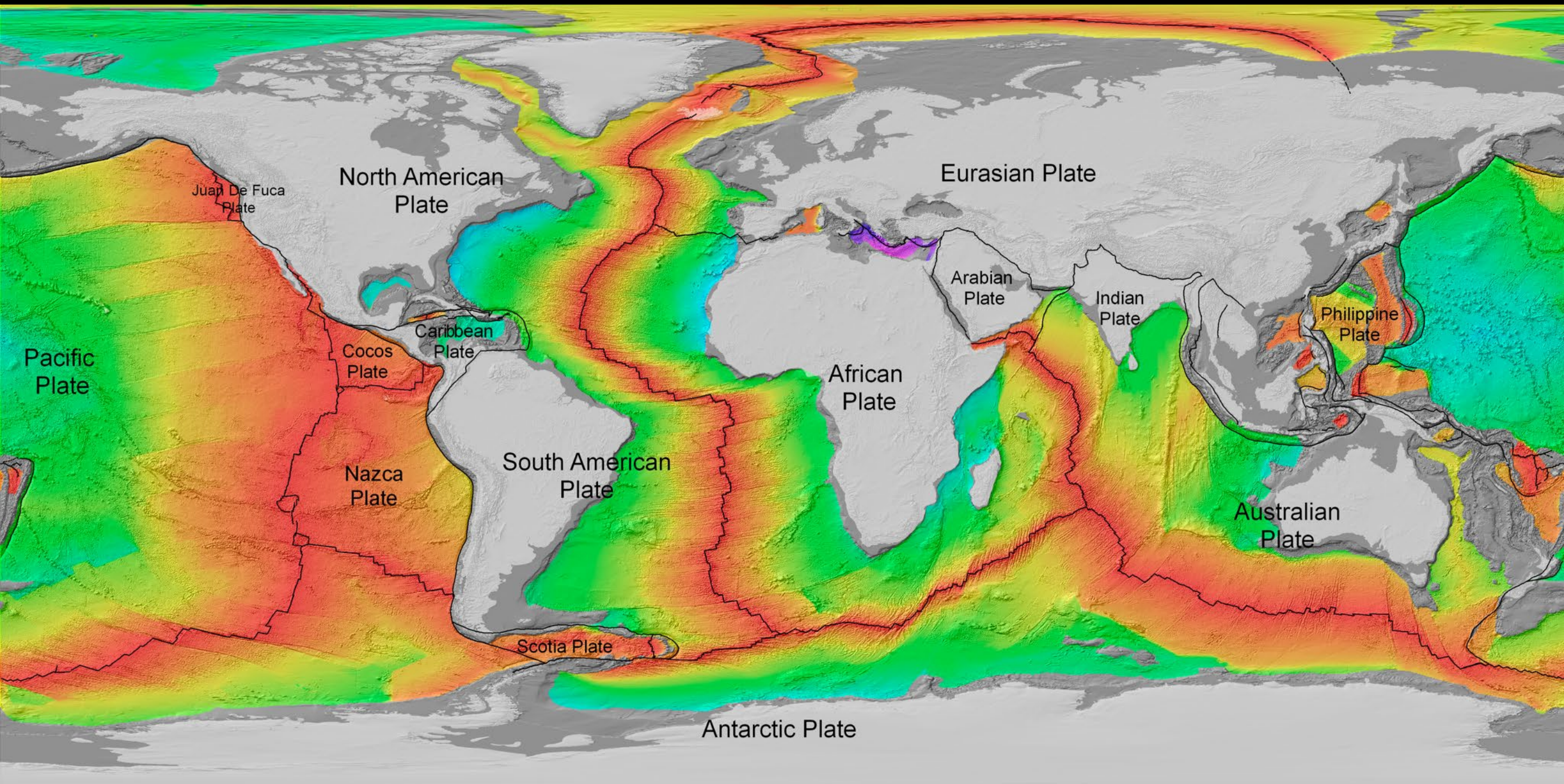
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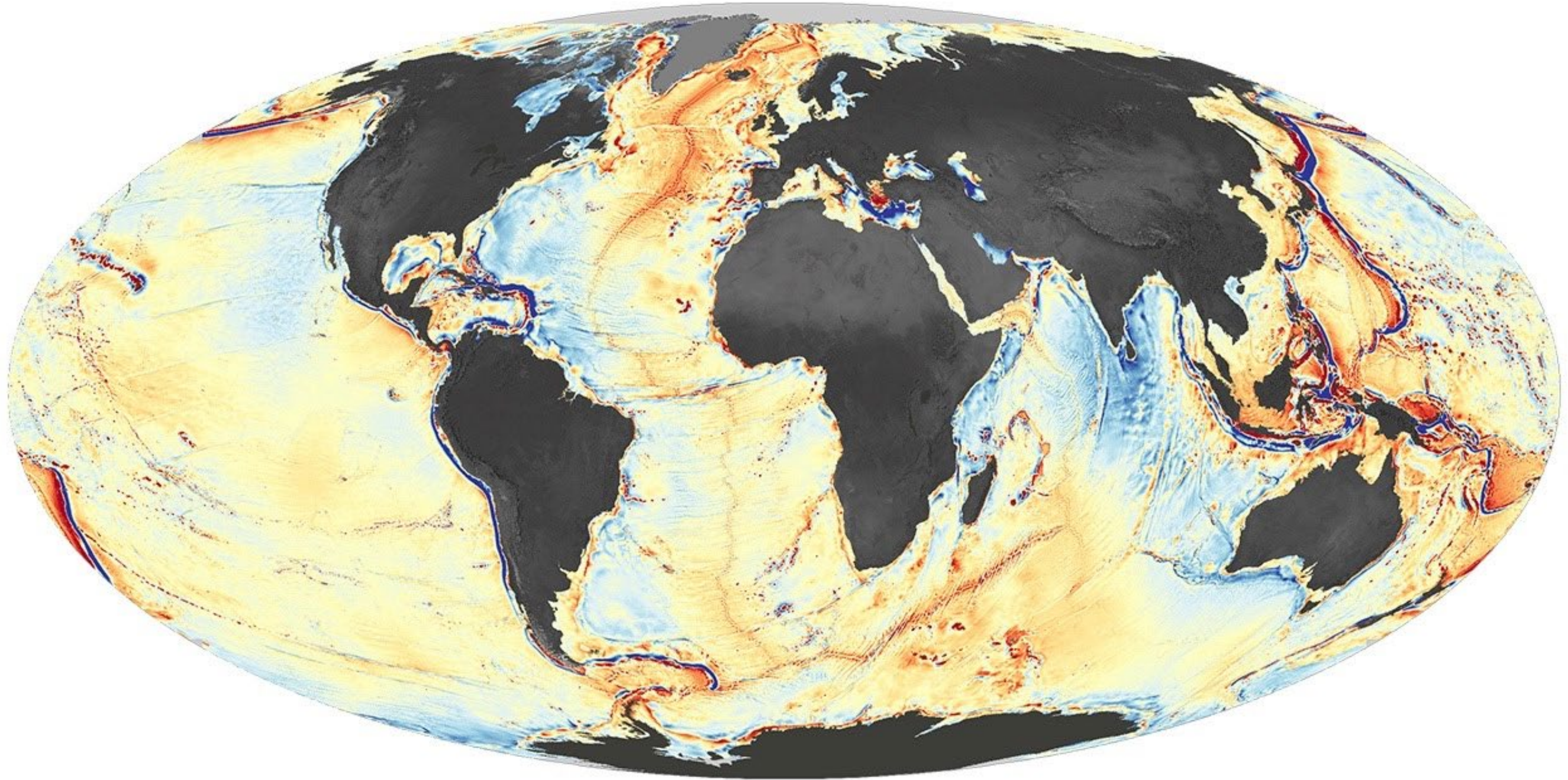
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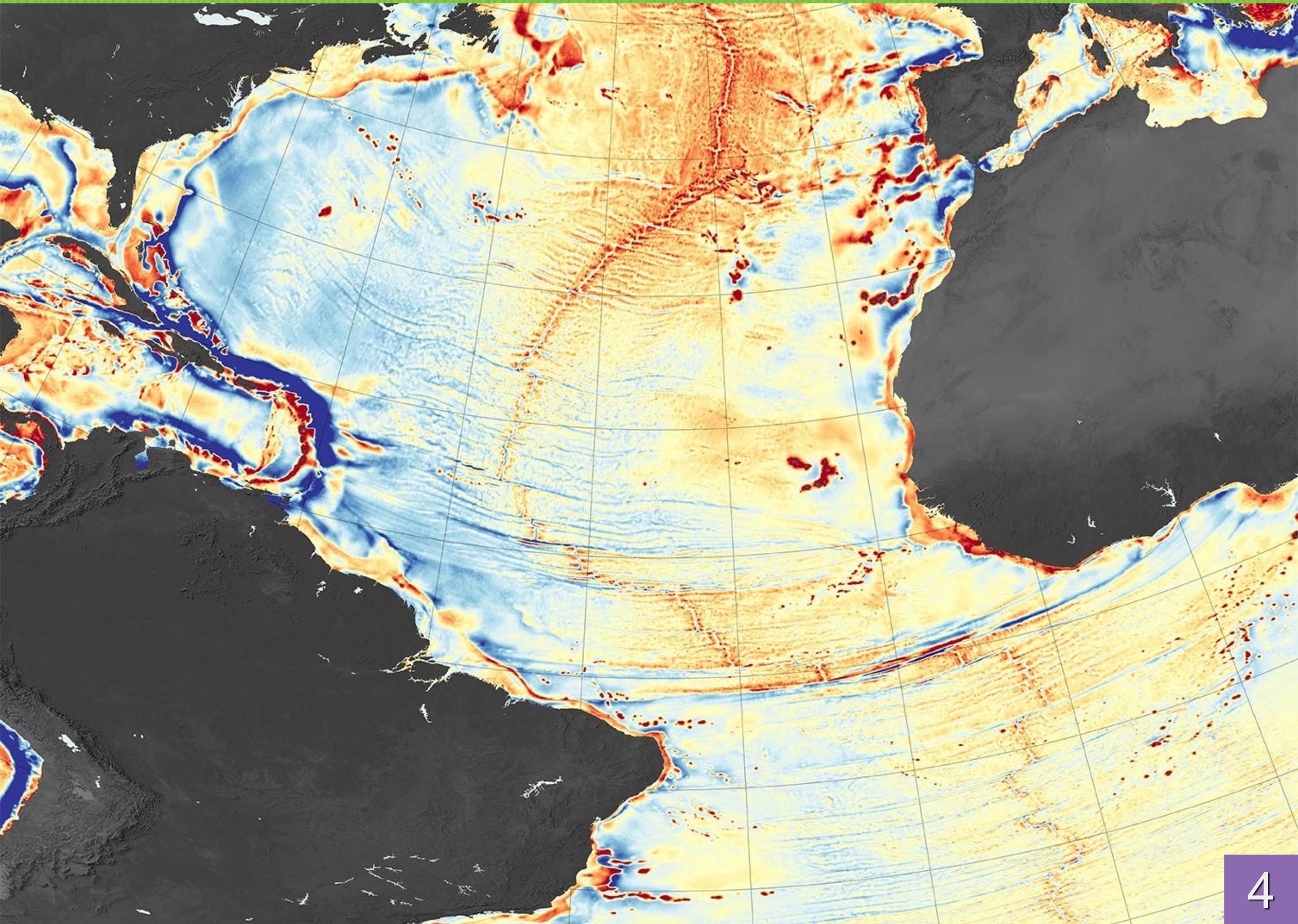
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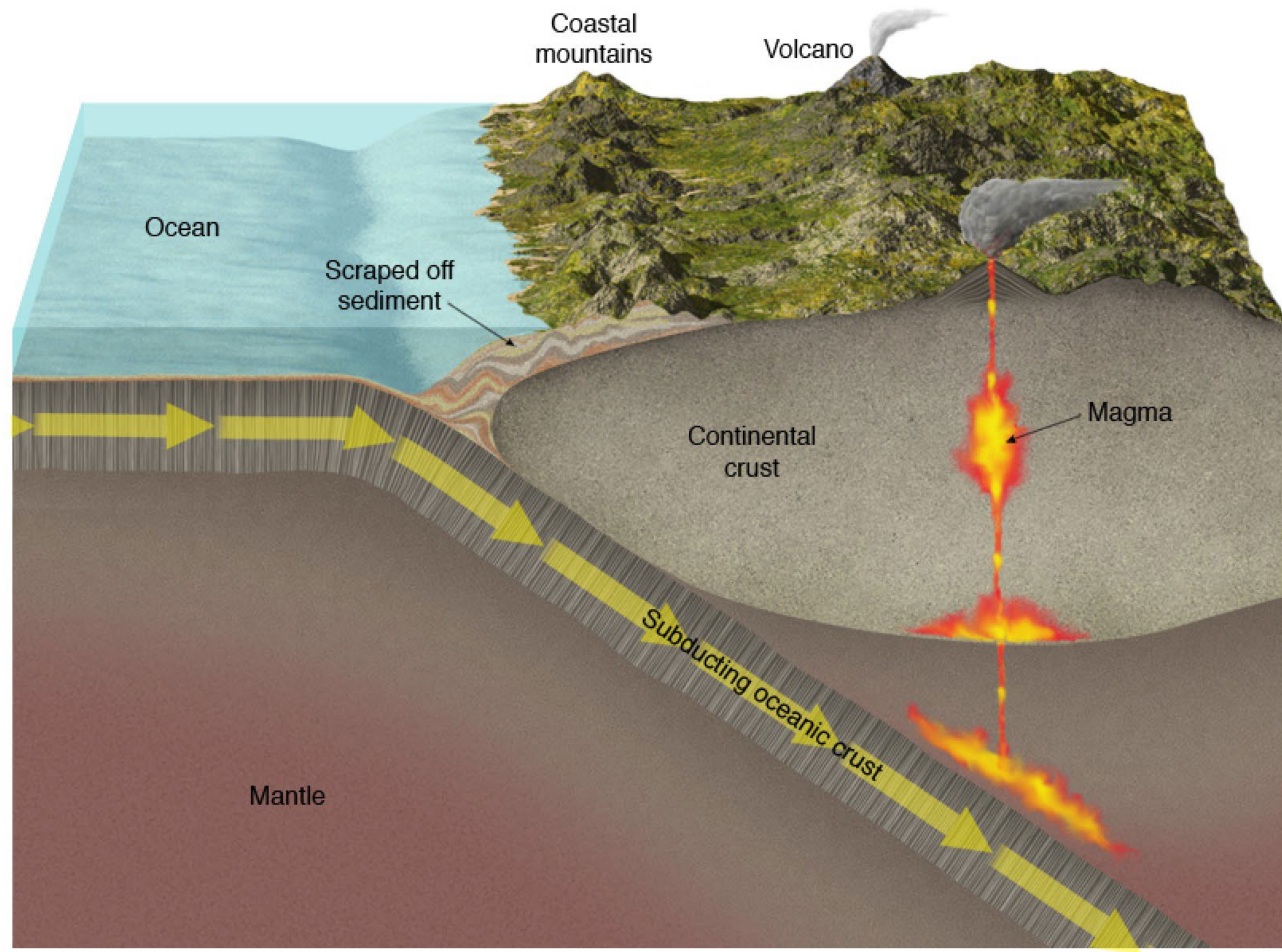
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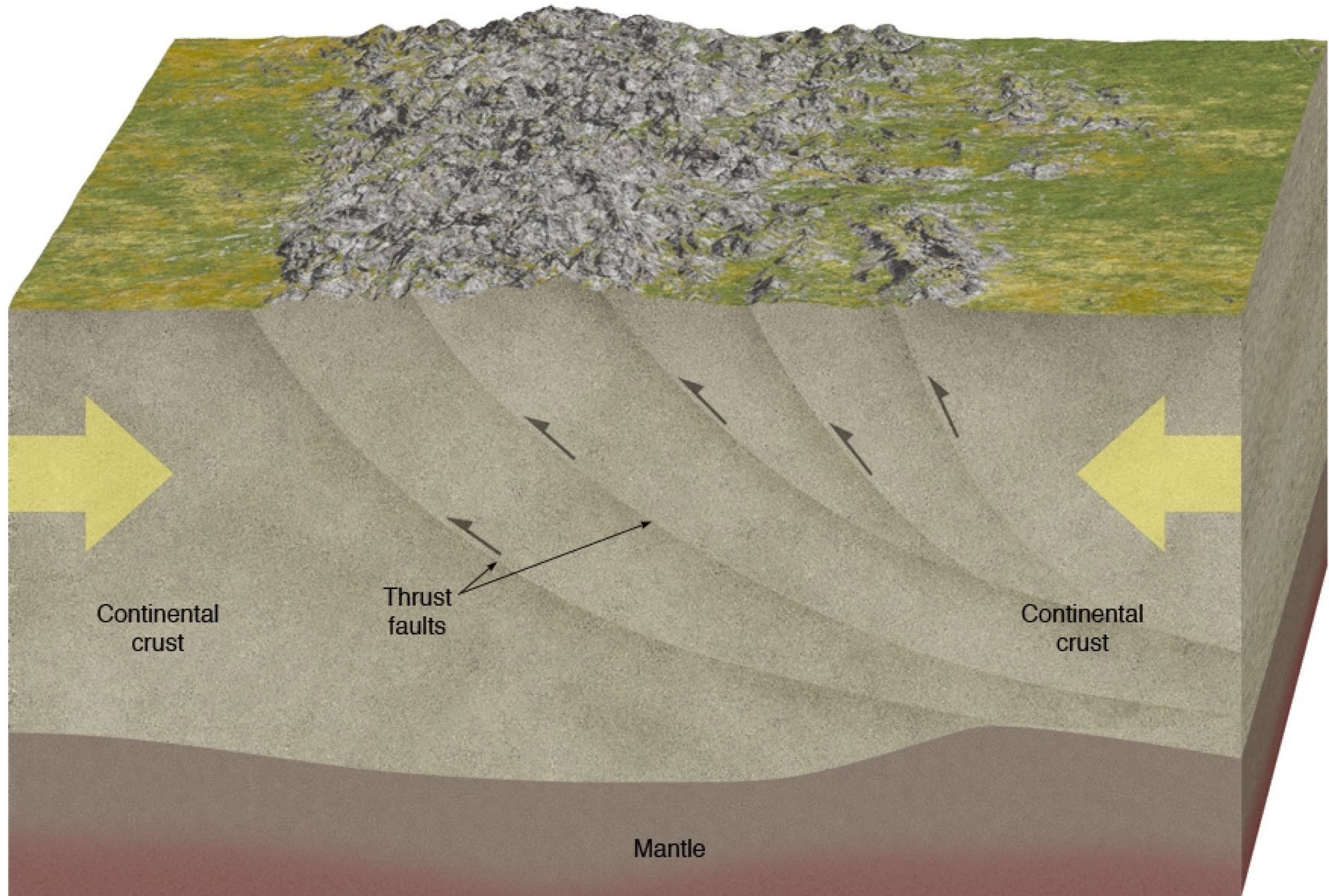


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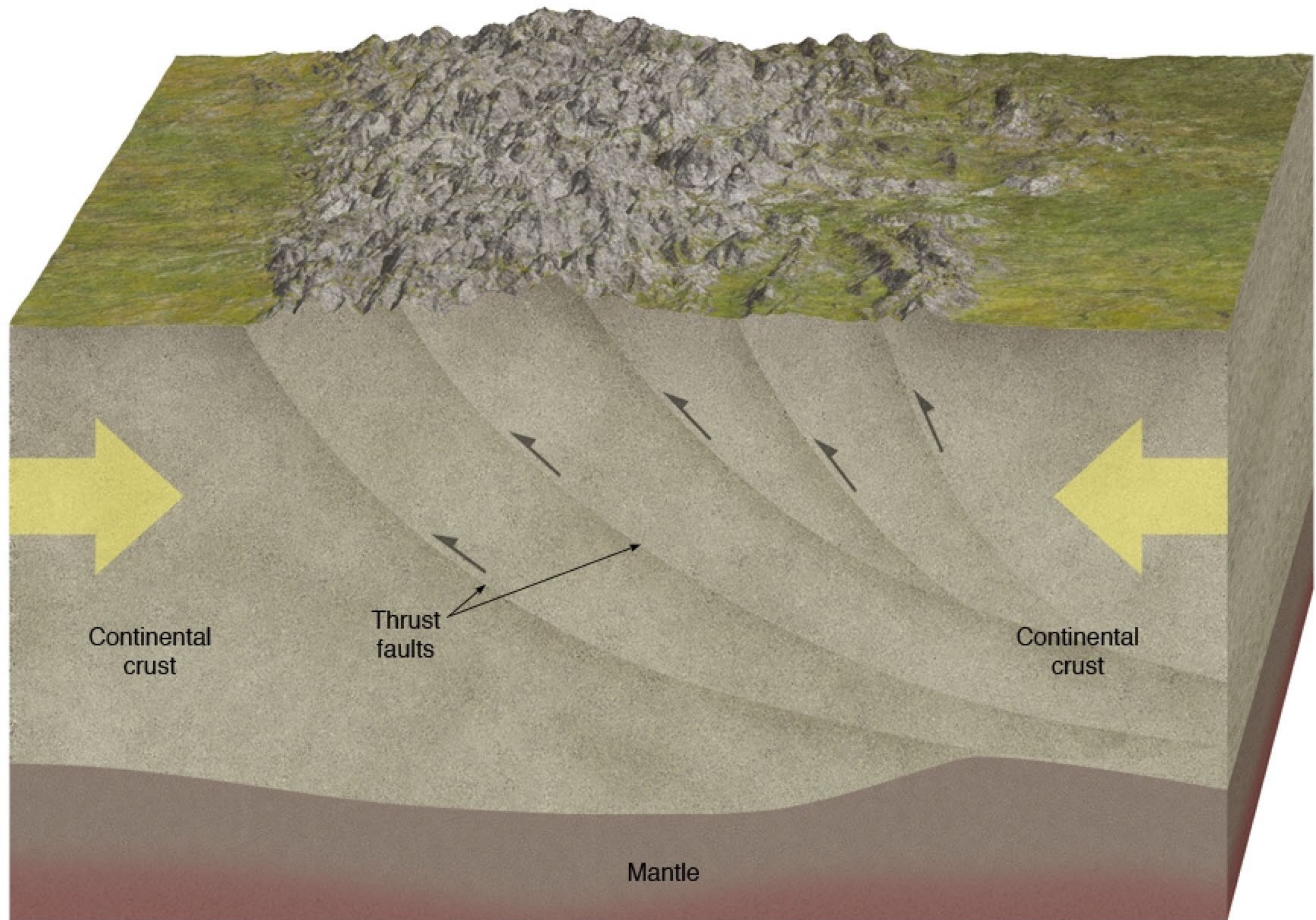


Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat

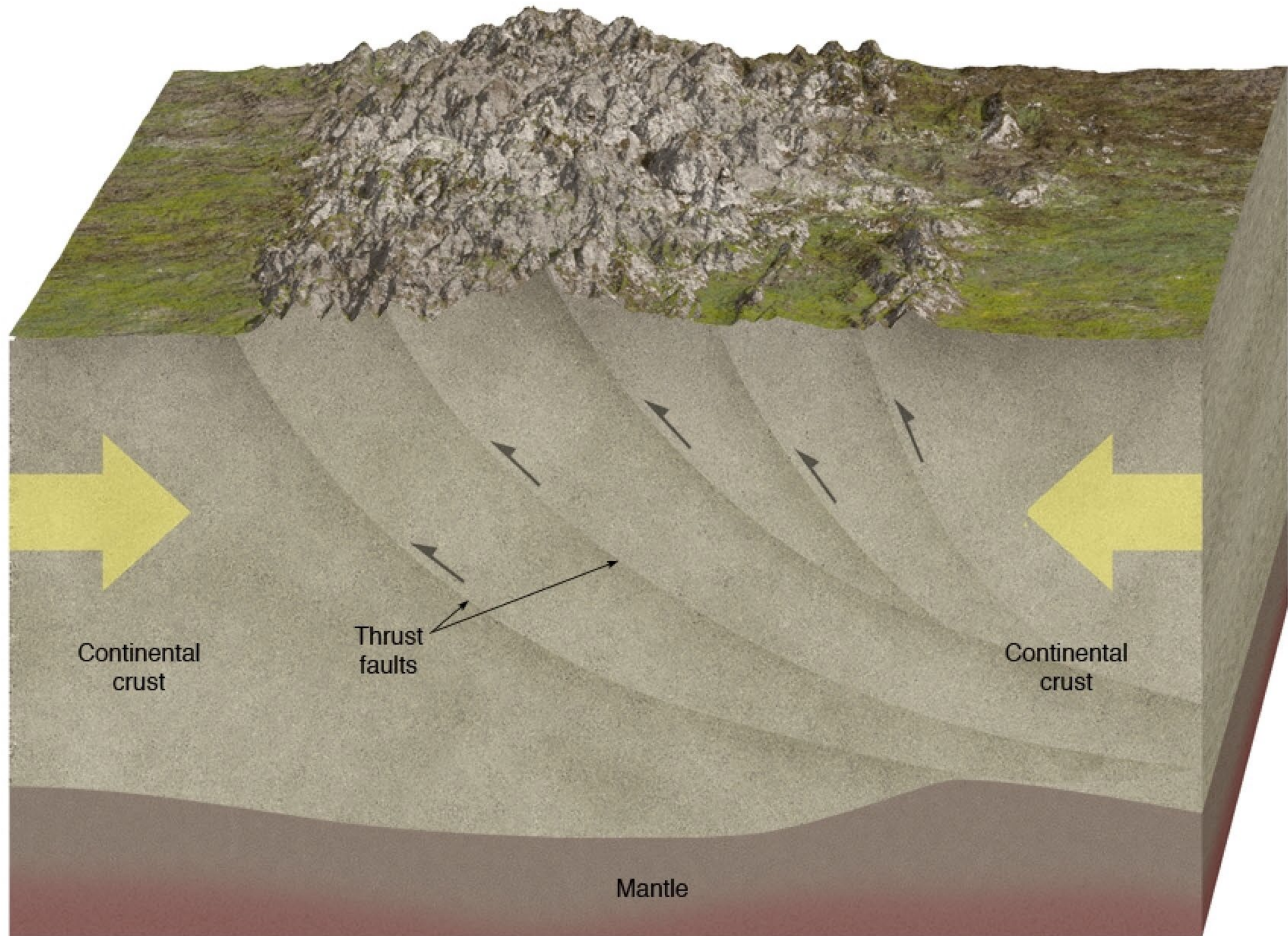
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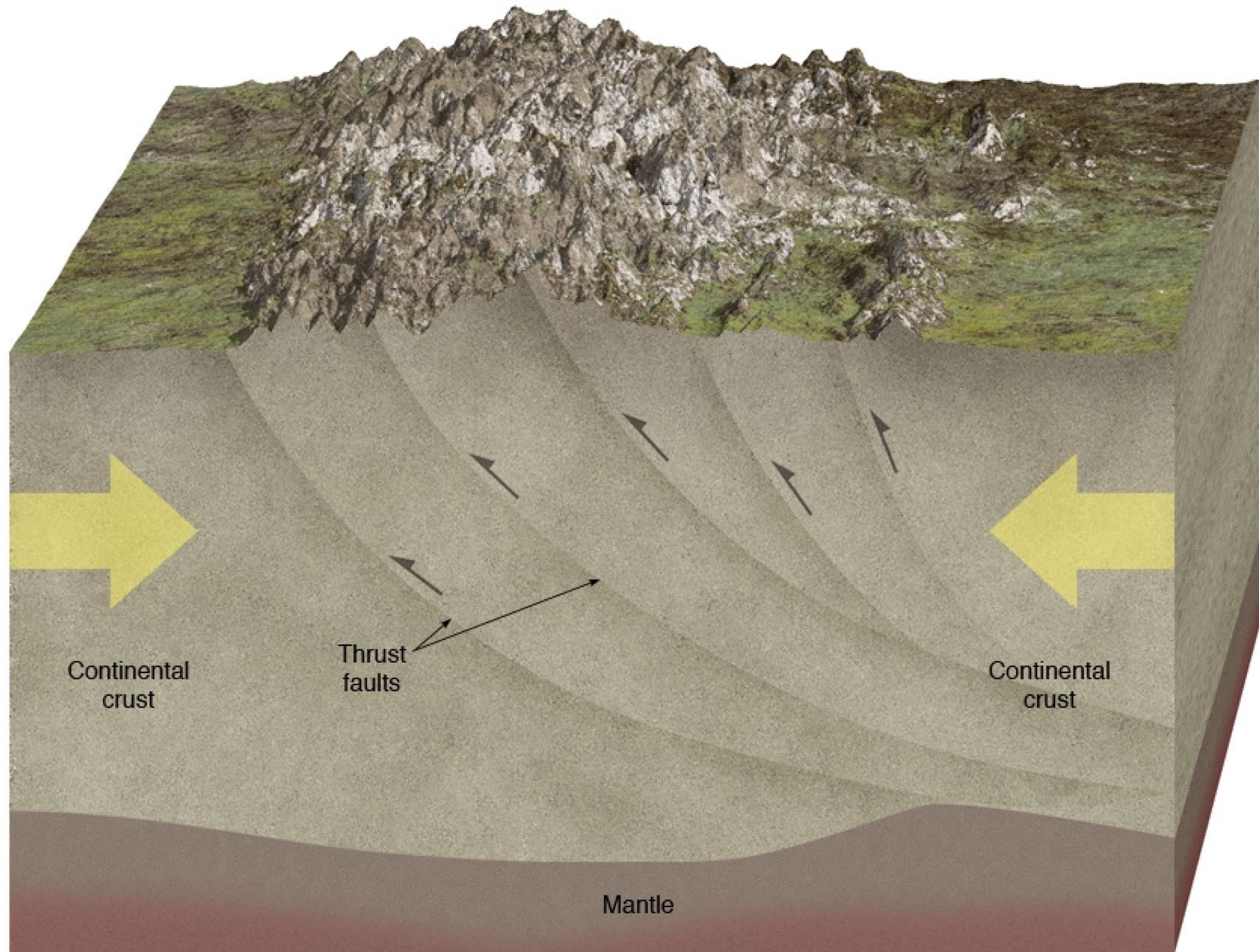
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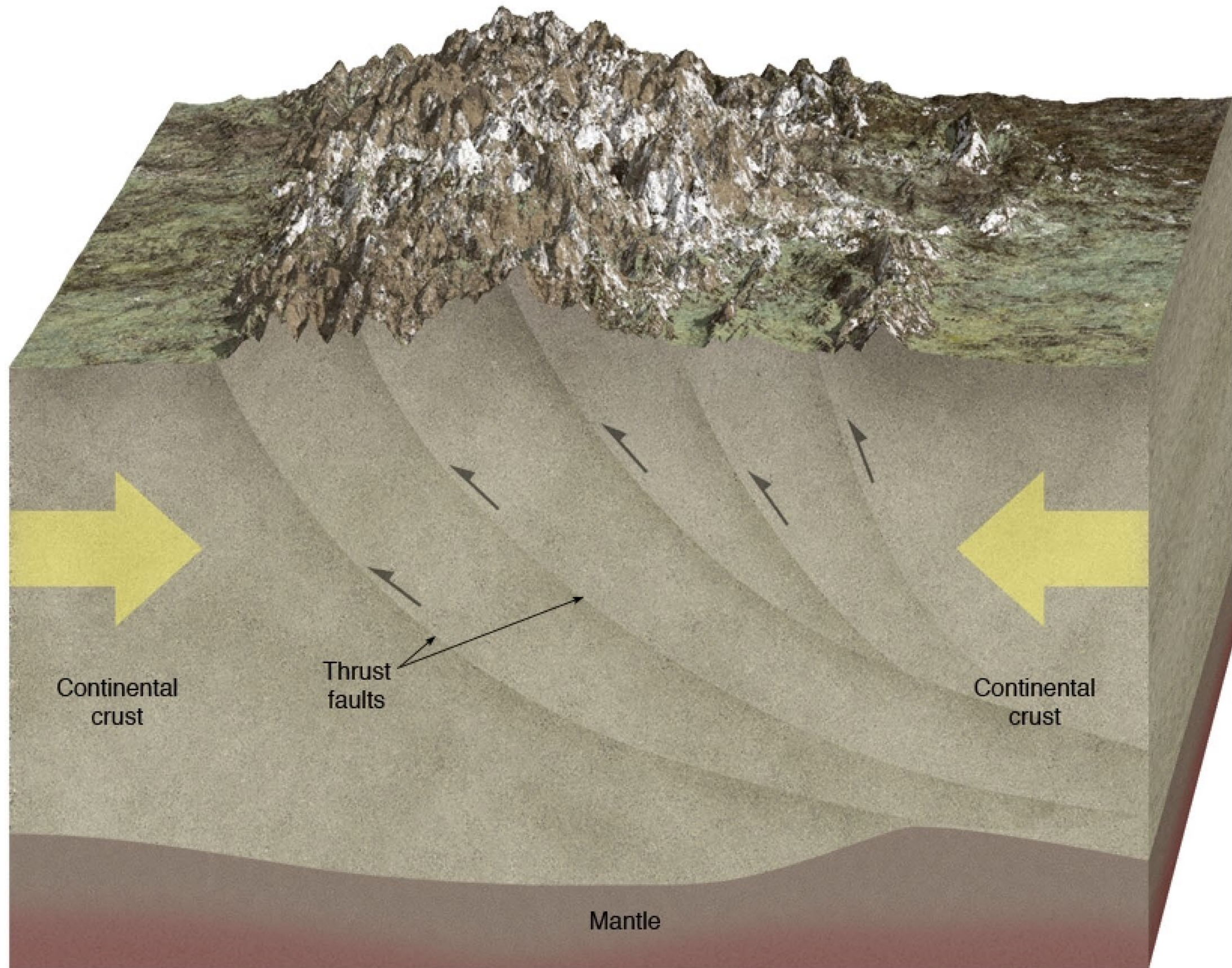
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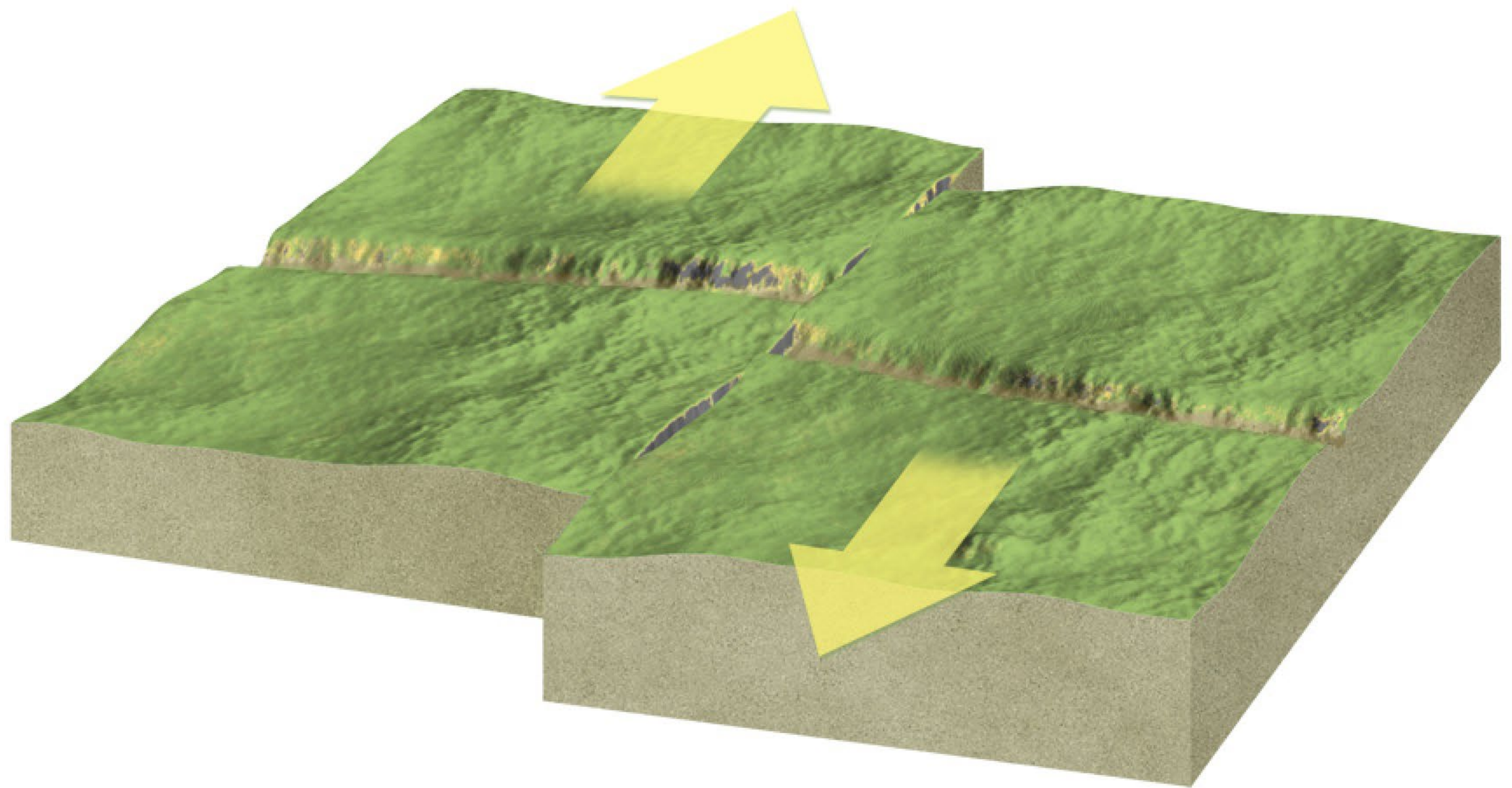
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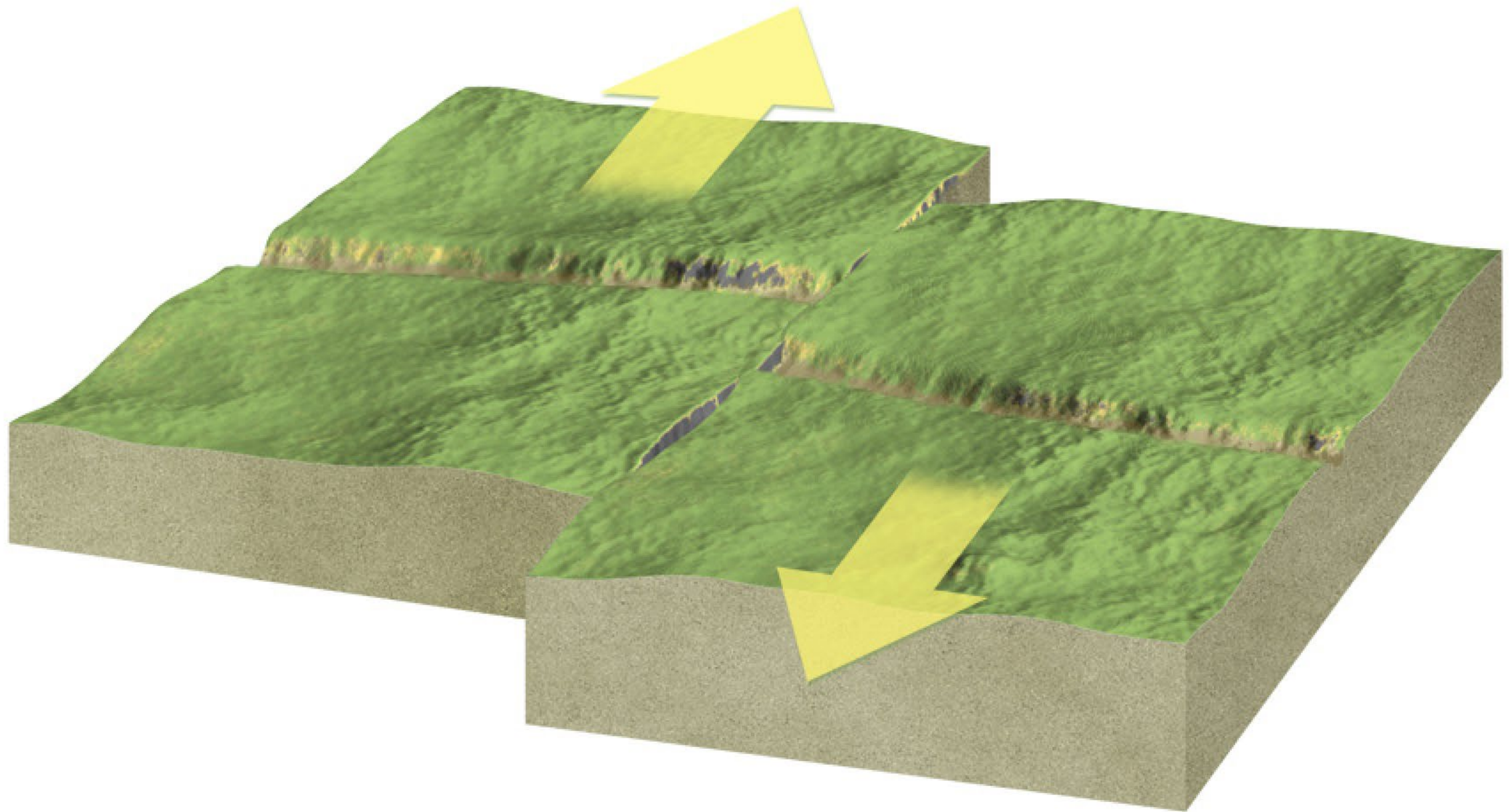
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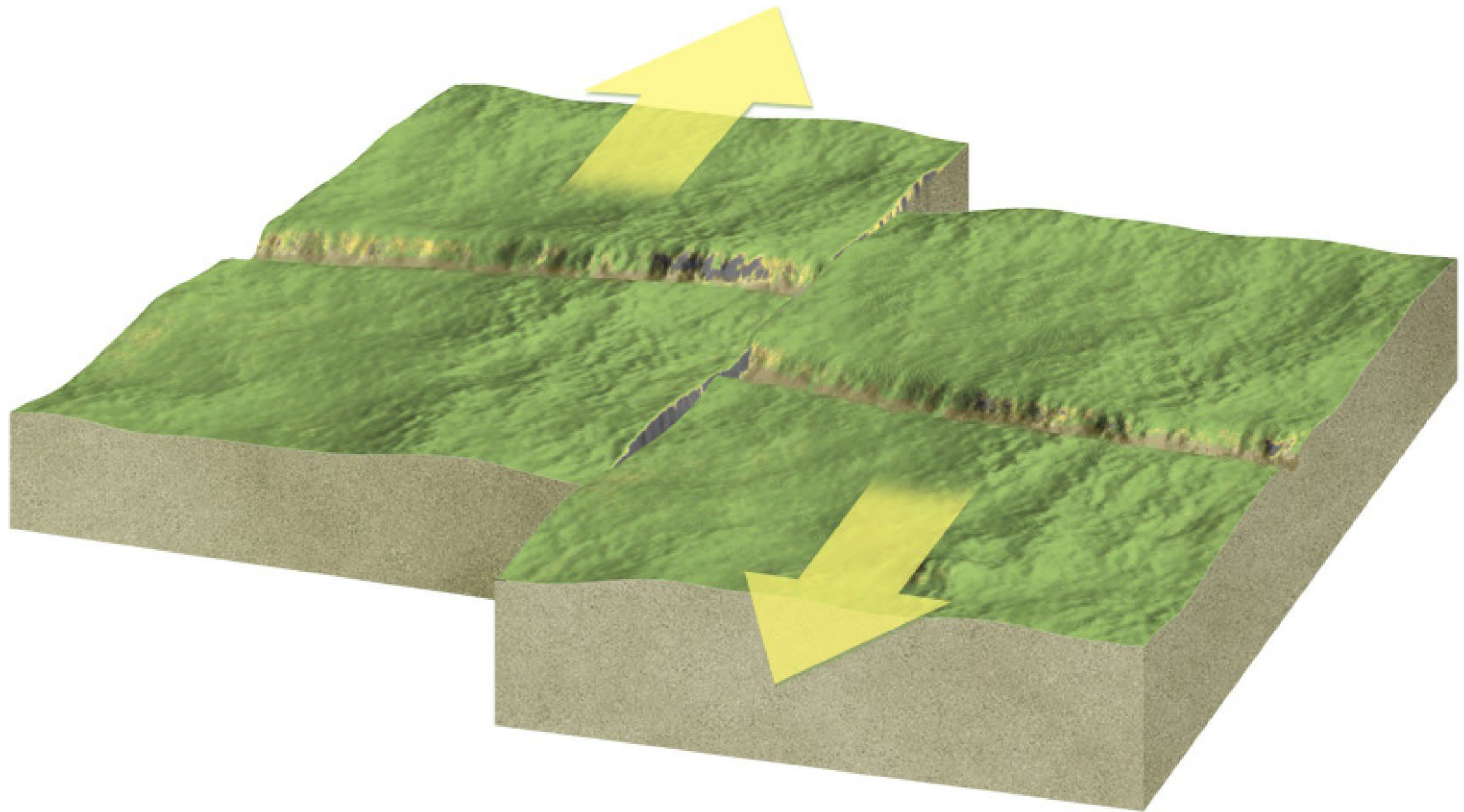
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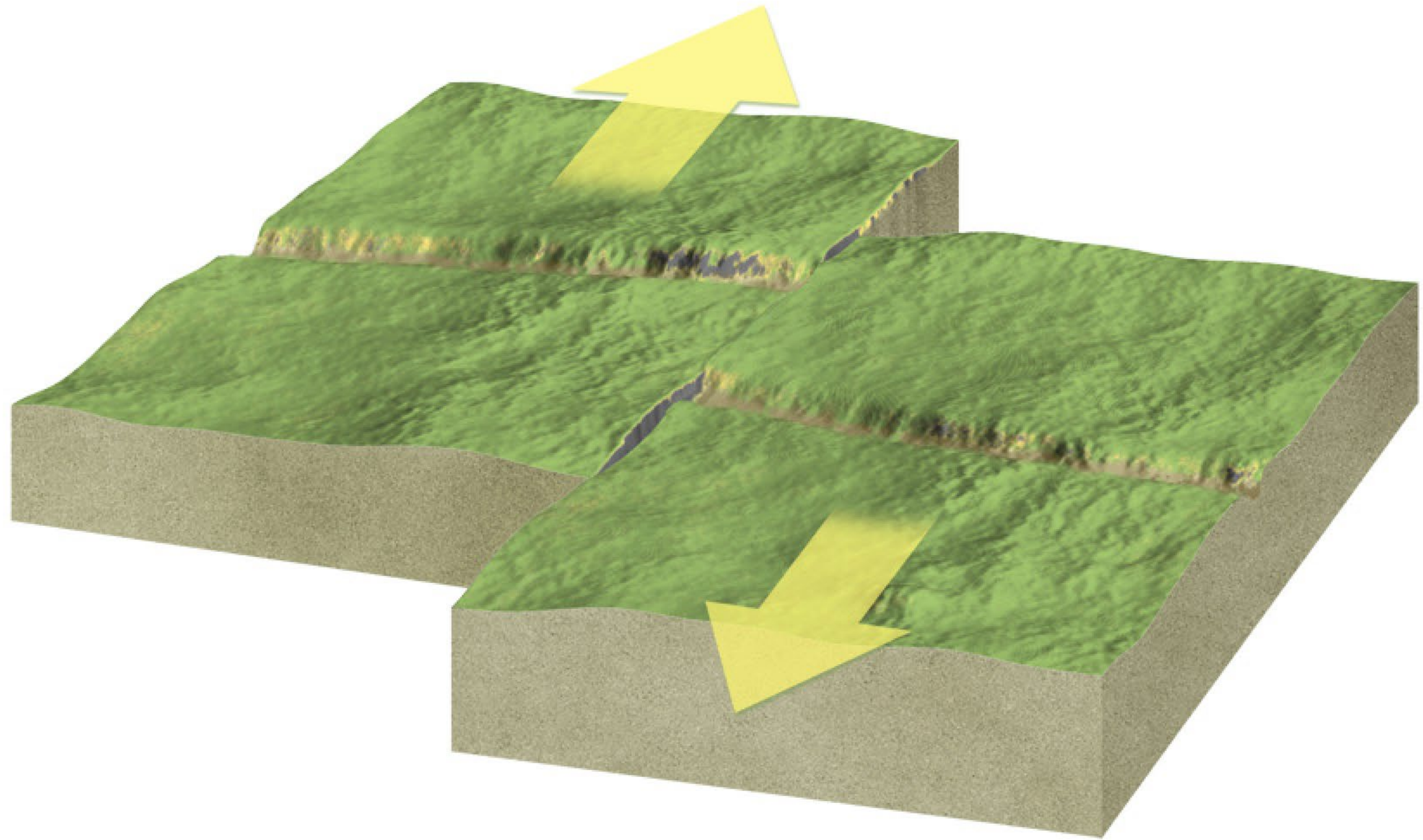
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Carrizo Plain, California



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Carrizo Plain, California

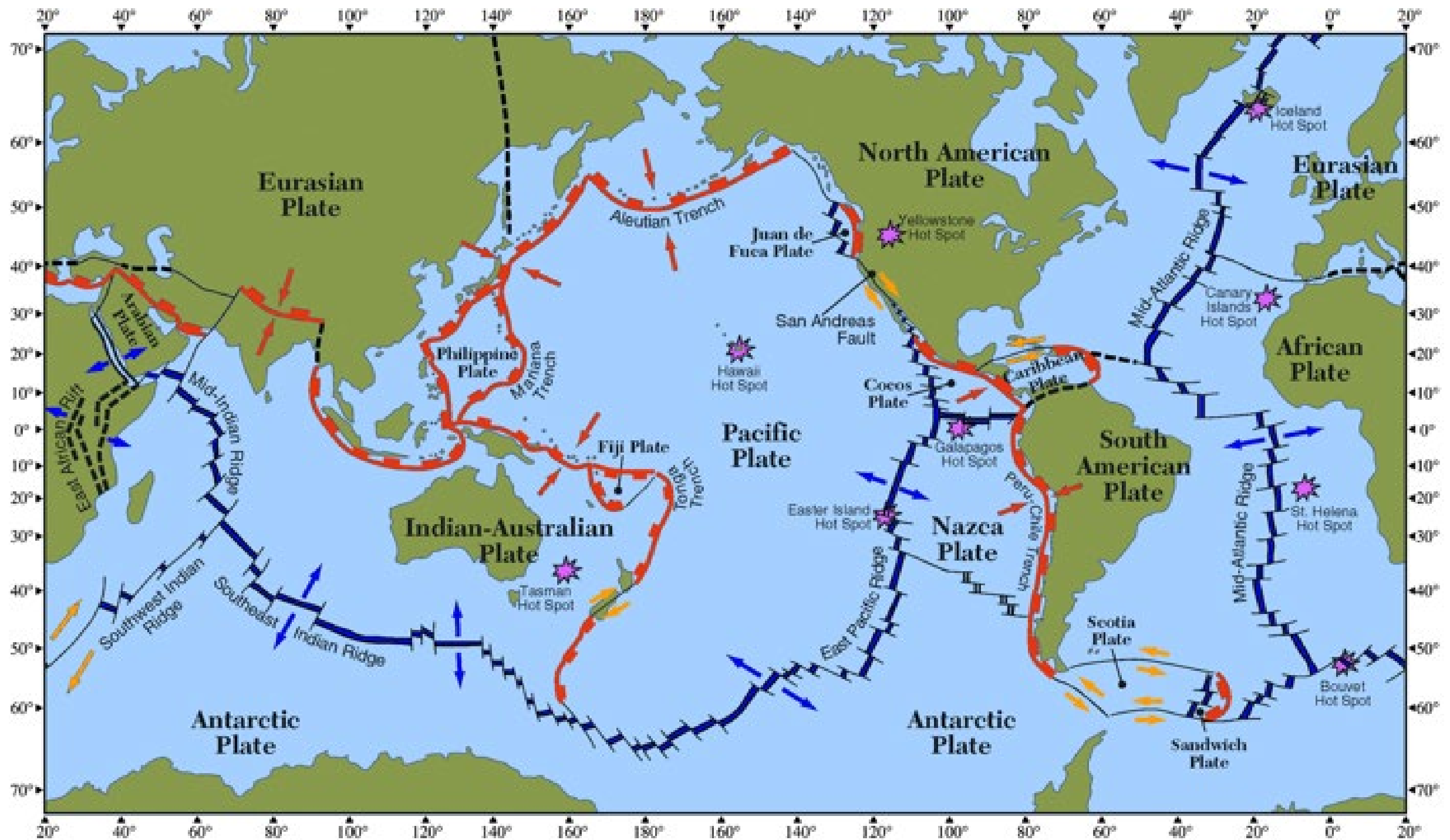


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Tectonic Plates



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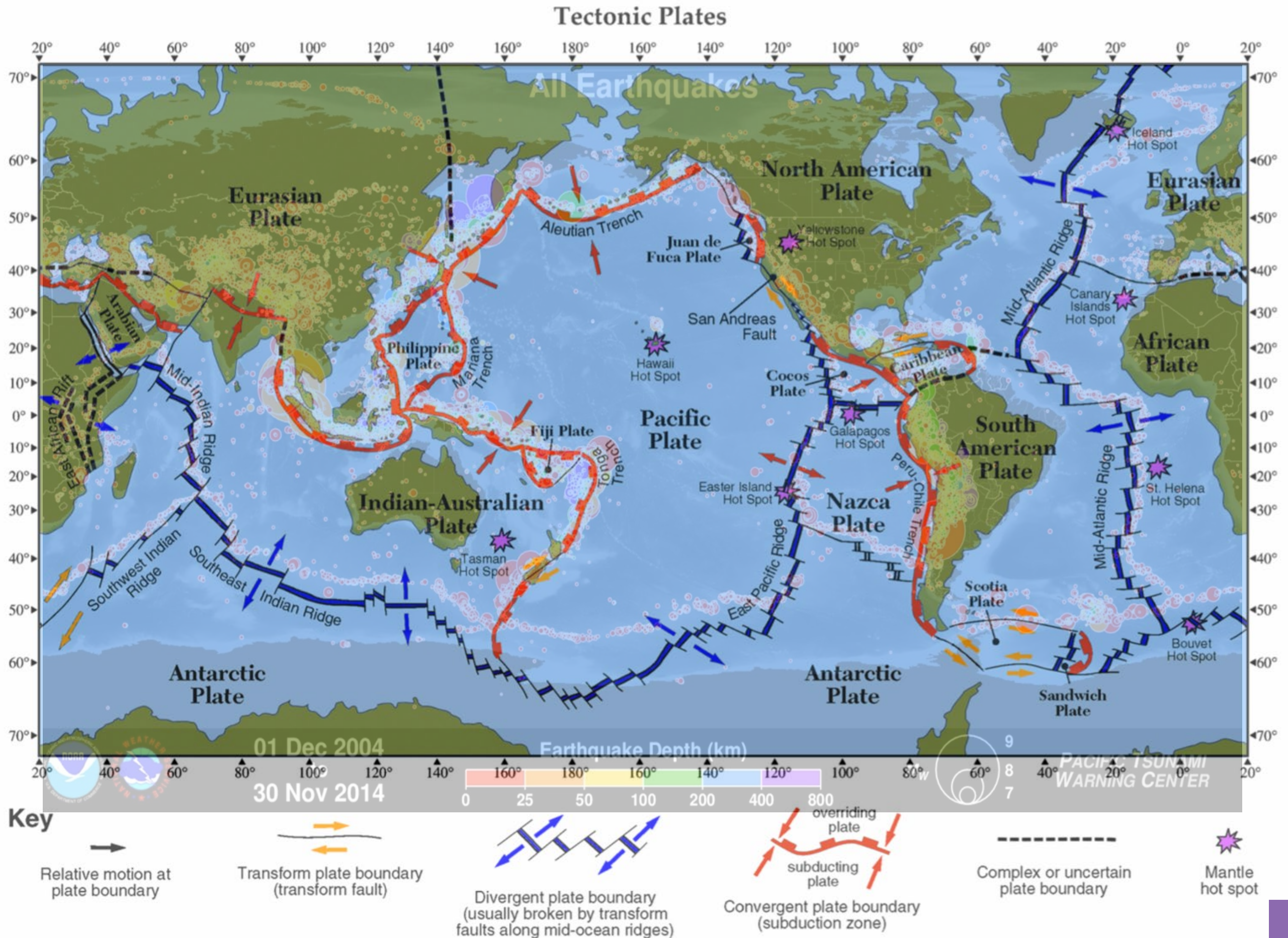
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Complex or uncertain
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Mantle
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NOTE: Not all mantle hot spots, plates, and boundaries are shown.

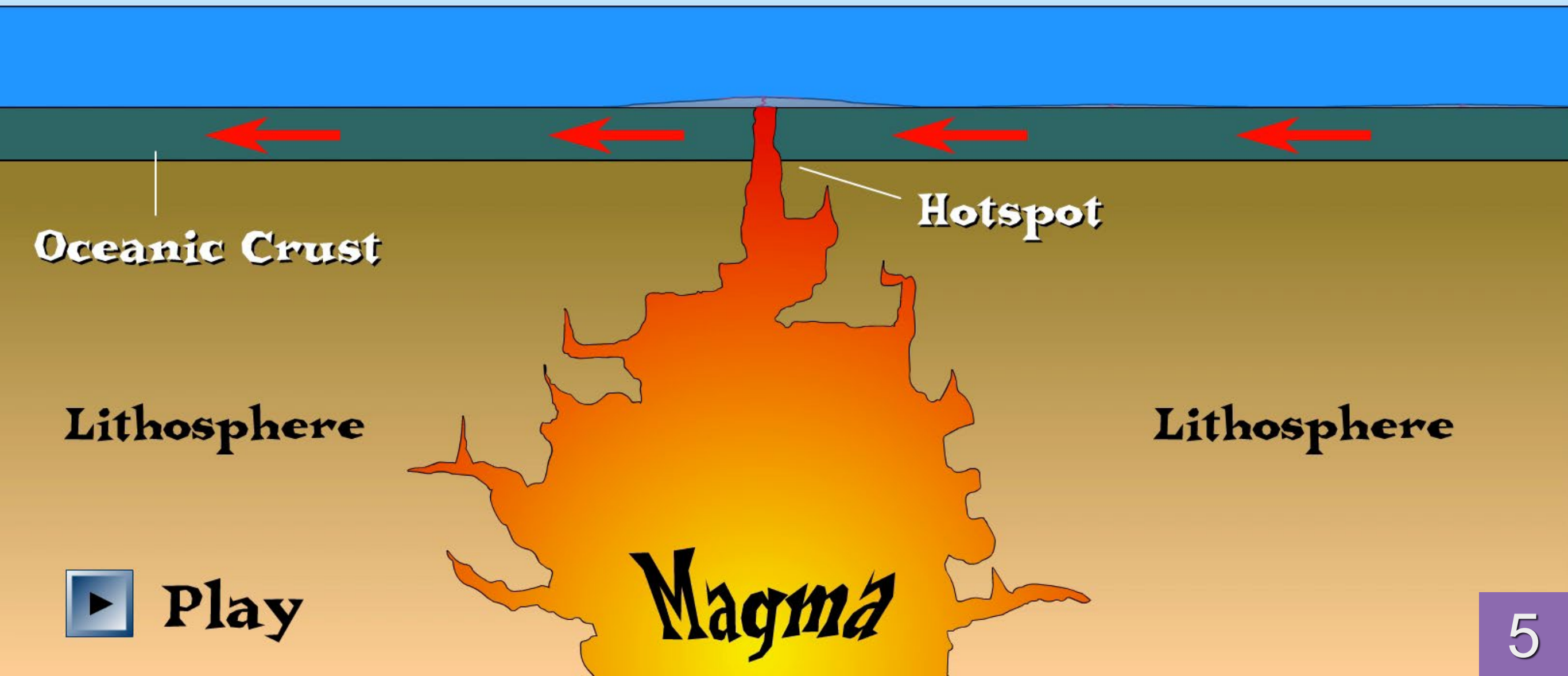
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What is a hot spot?

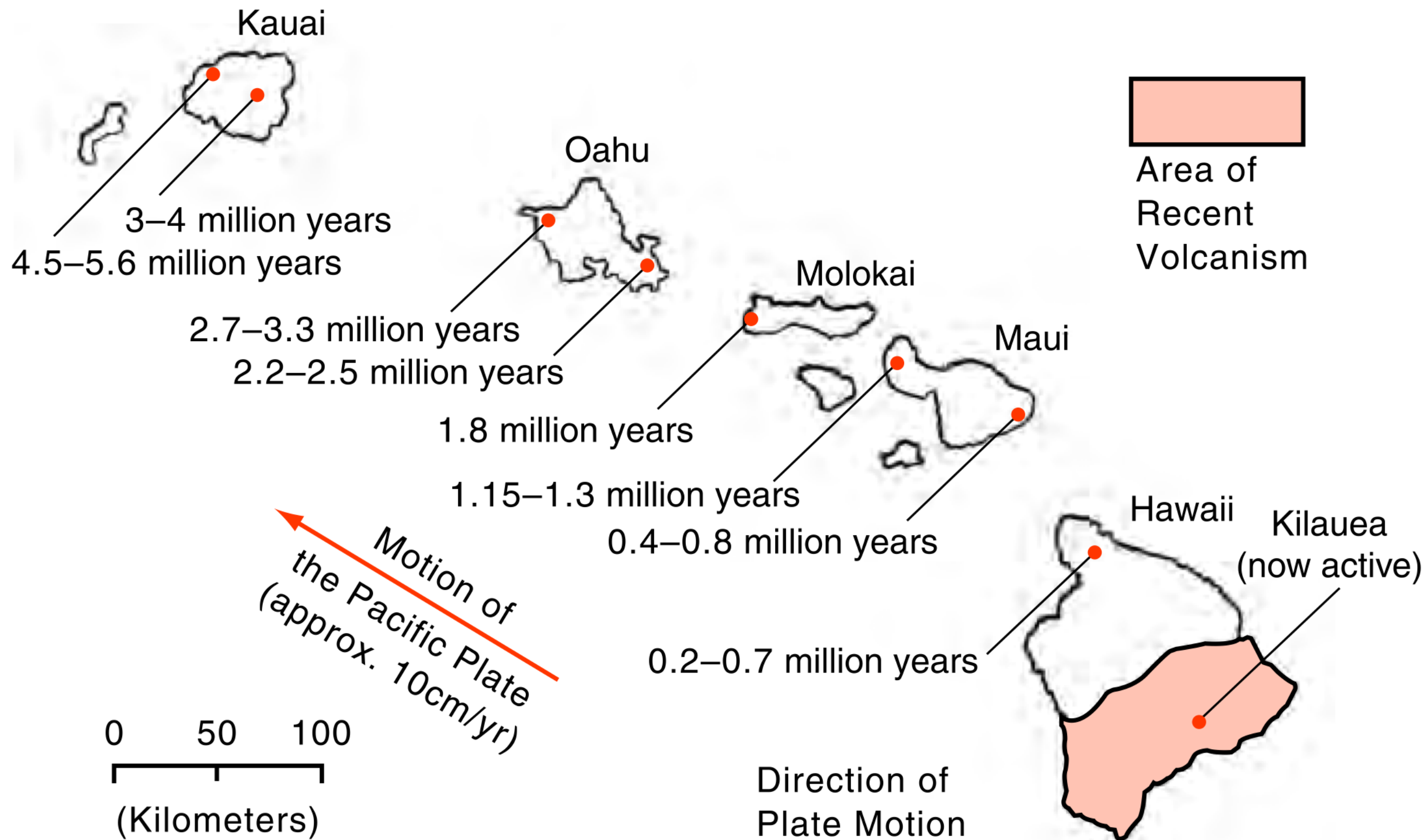
- **Hotspot** - a long-lived source of **magma** within the asthenosphere and below the moving lithospheric plates.

Hotspots and the Hawaiian islands

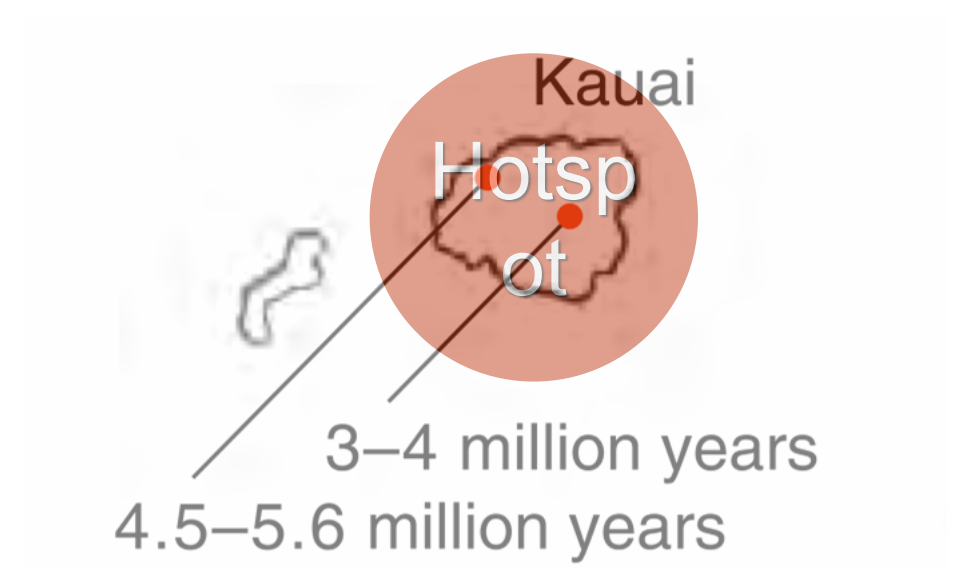


Play

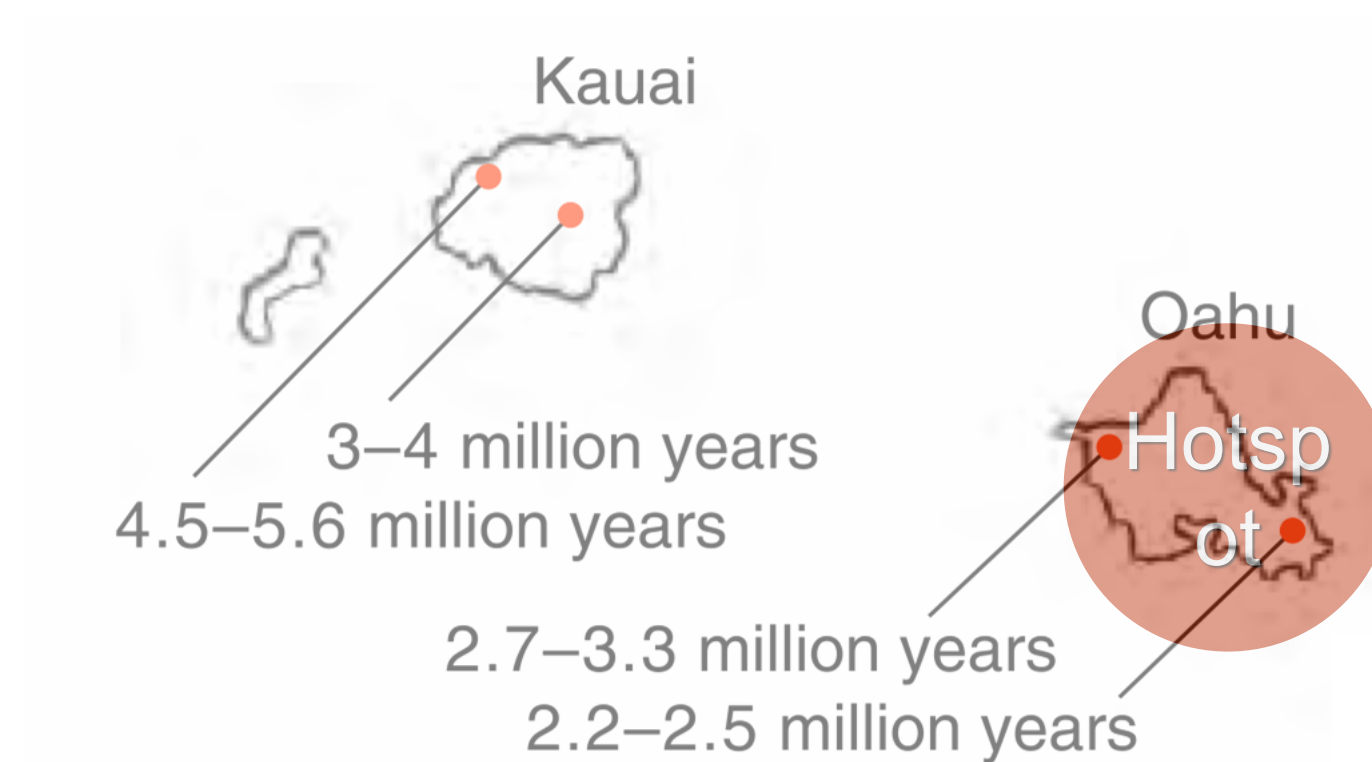
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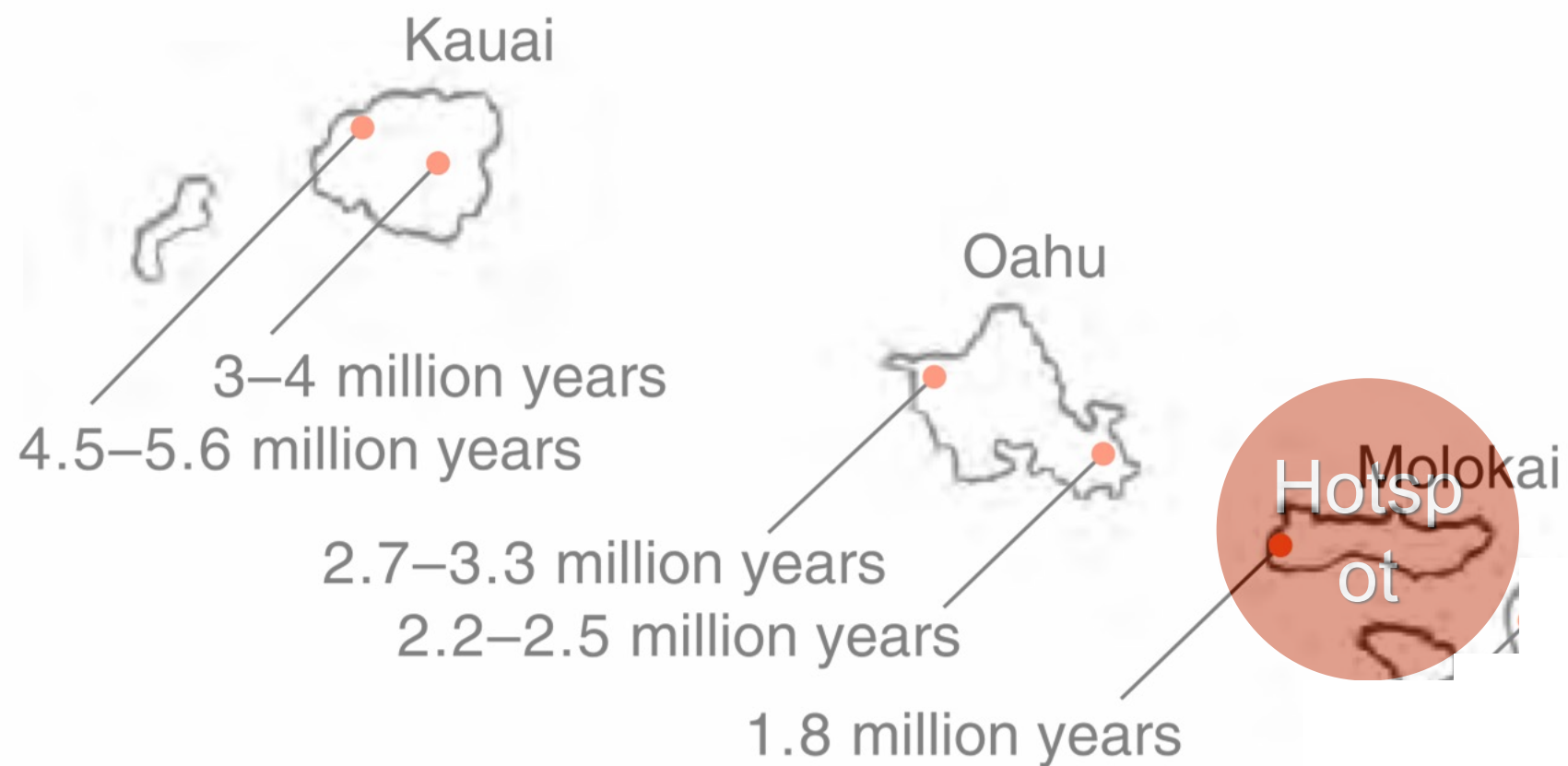
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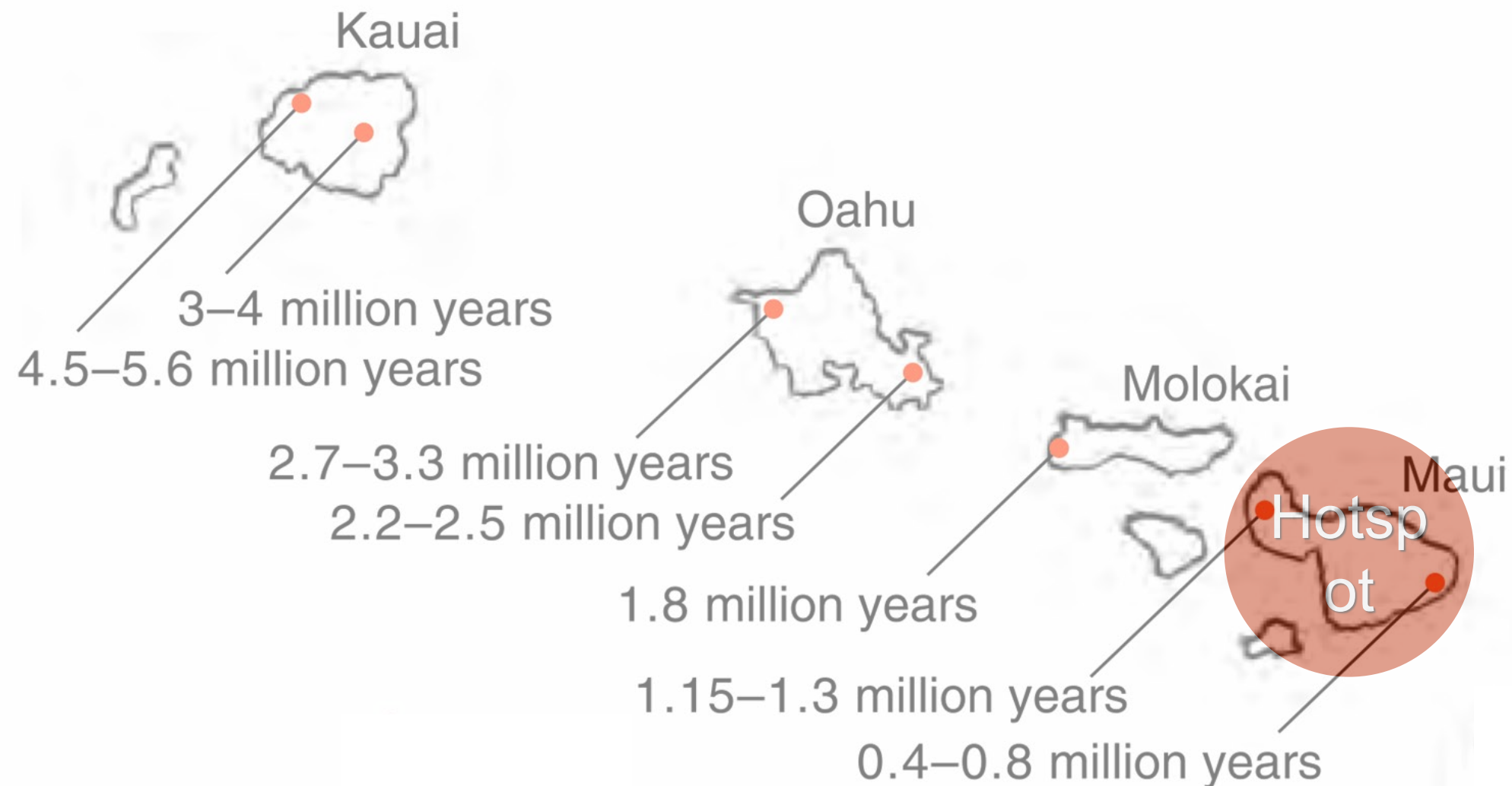
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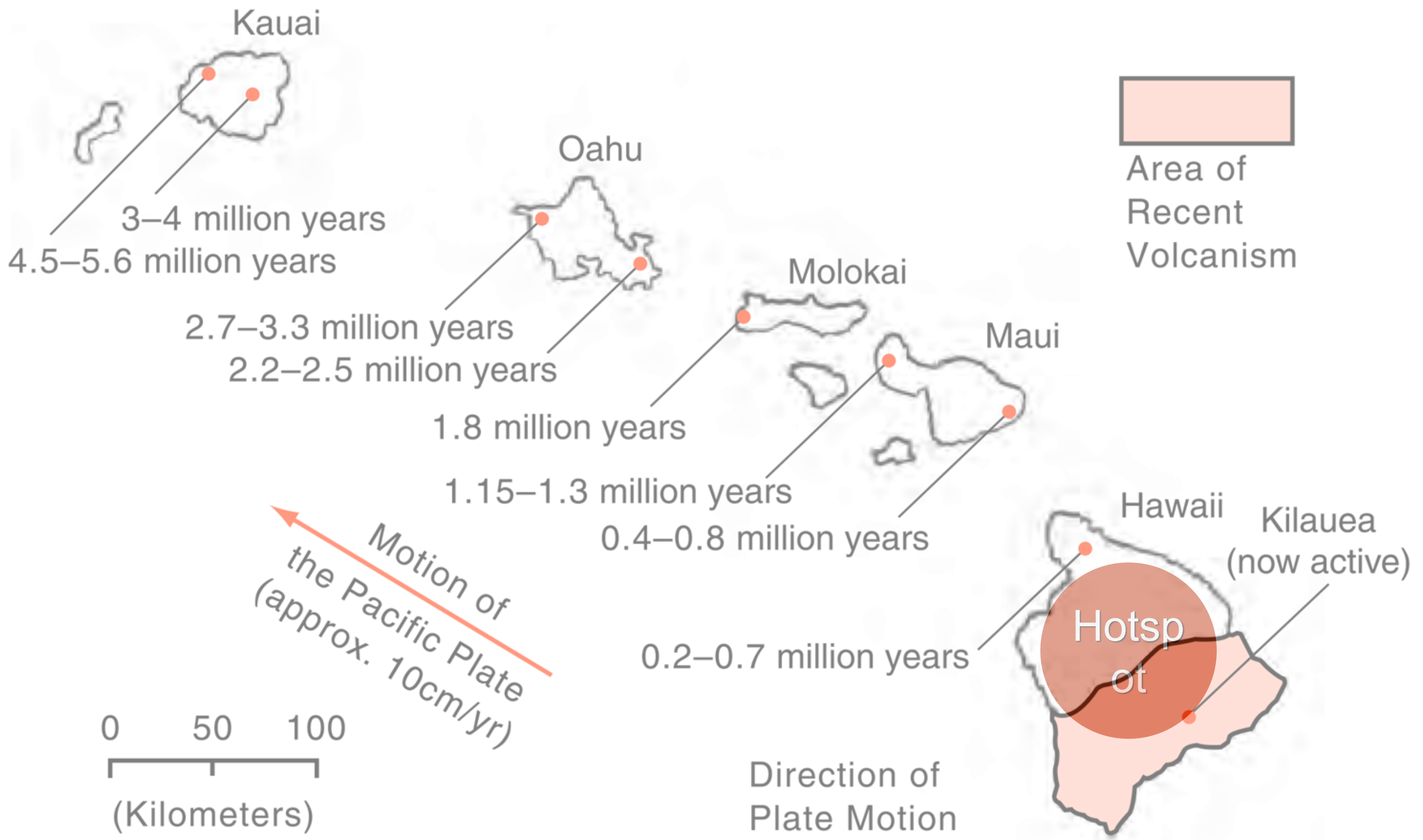
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Sep. 25, 2012

Pu'u 'Ō'ō Crater

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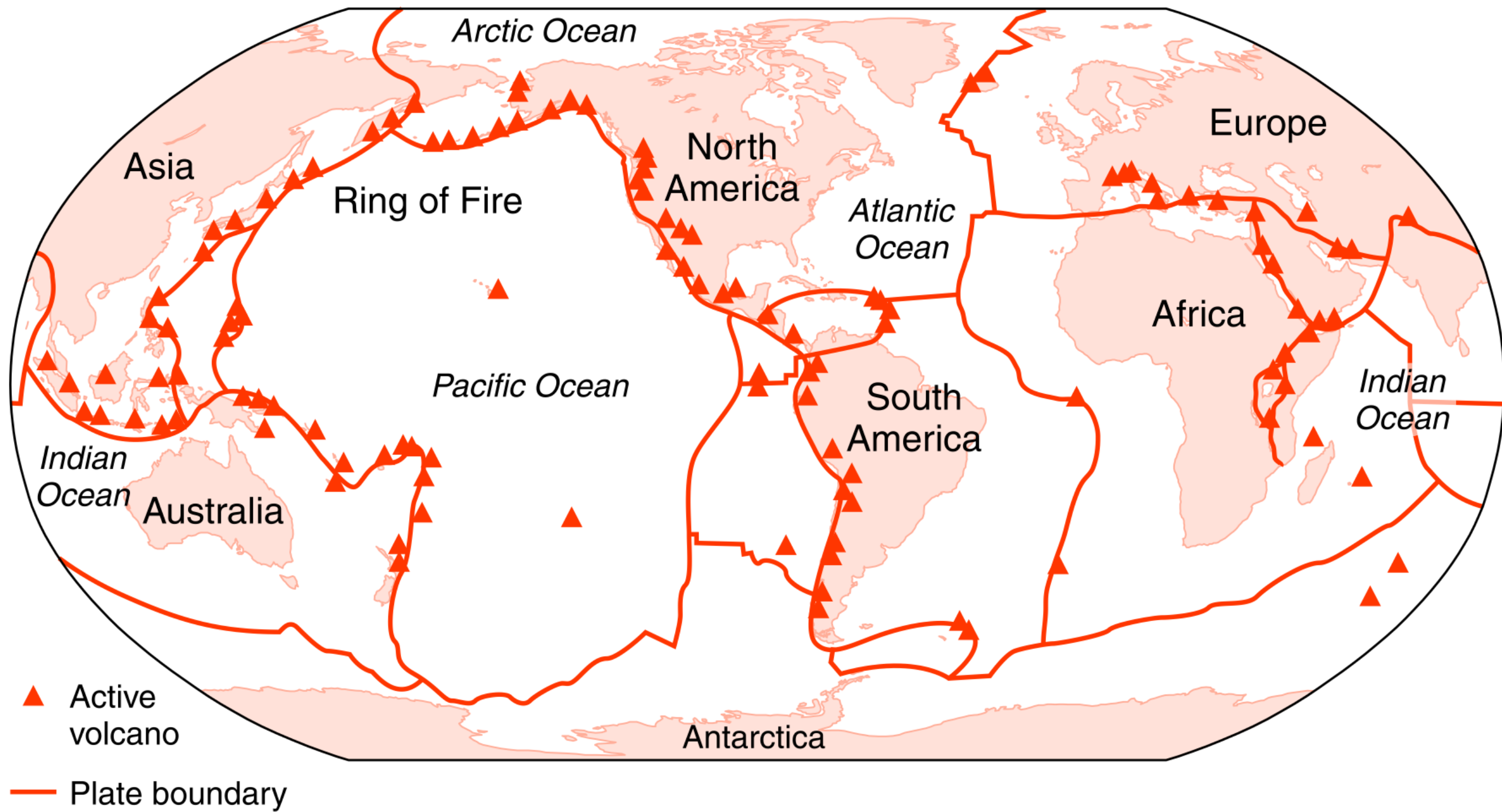
Geologic Hazards

- **Earthquake** - a sudden **movement** of Earth's crust that releases energy.
- **Volcano** - an opening in Earth's surface through which molten **magma** erupts.

Where do earthquakes and volcanoes occur?

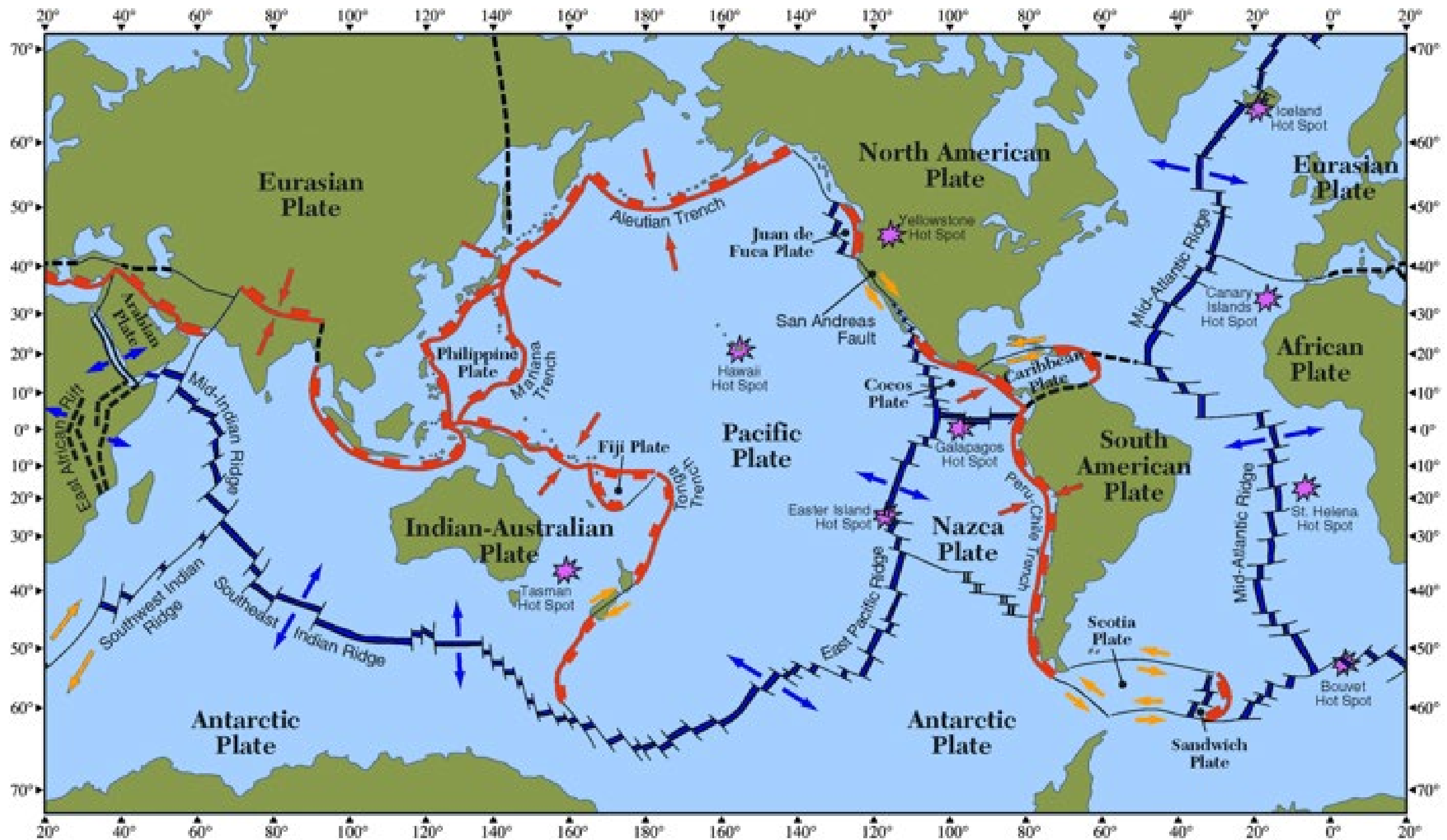
Goal: Students will be able to describe where an earthquake/volcano can occur.

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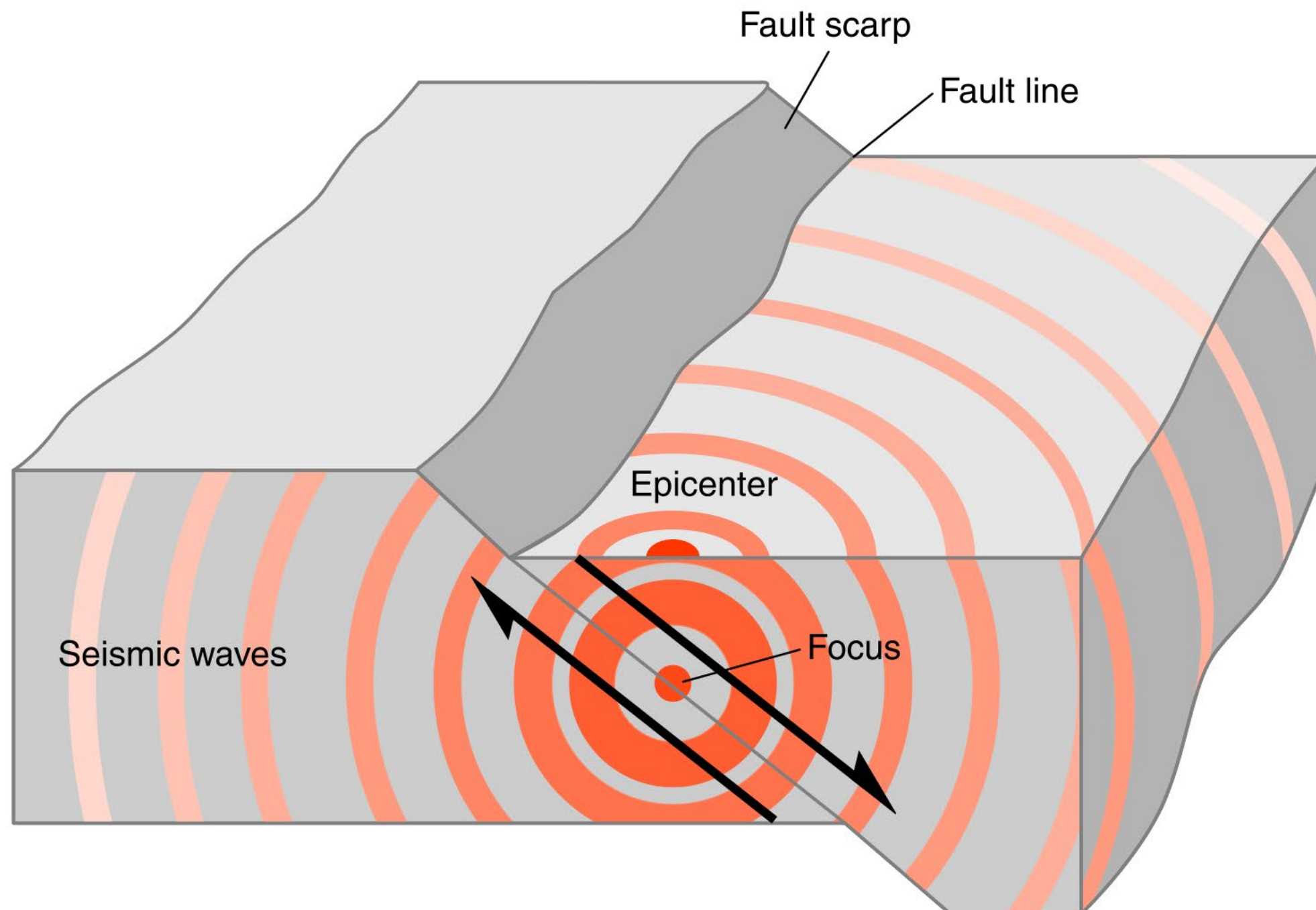
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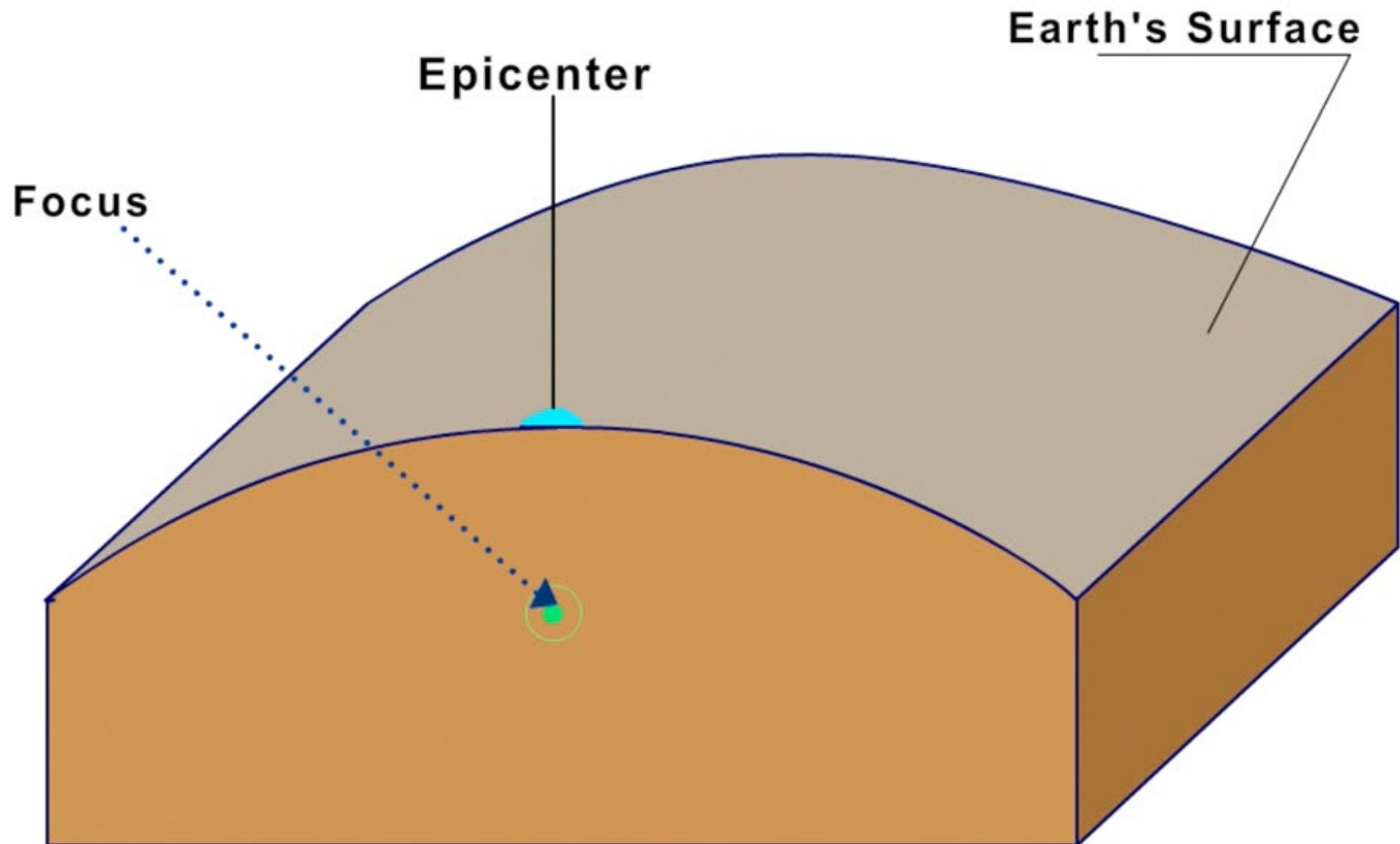
- Earthquakes and volcanoes occur along plate boundaries, where one plate moves along another plate.

Describing Where An Earthquake Occurs

Goal: Students will be able to describe where an earthquake occurs.



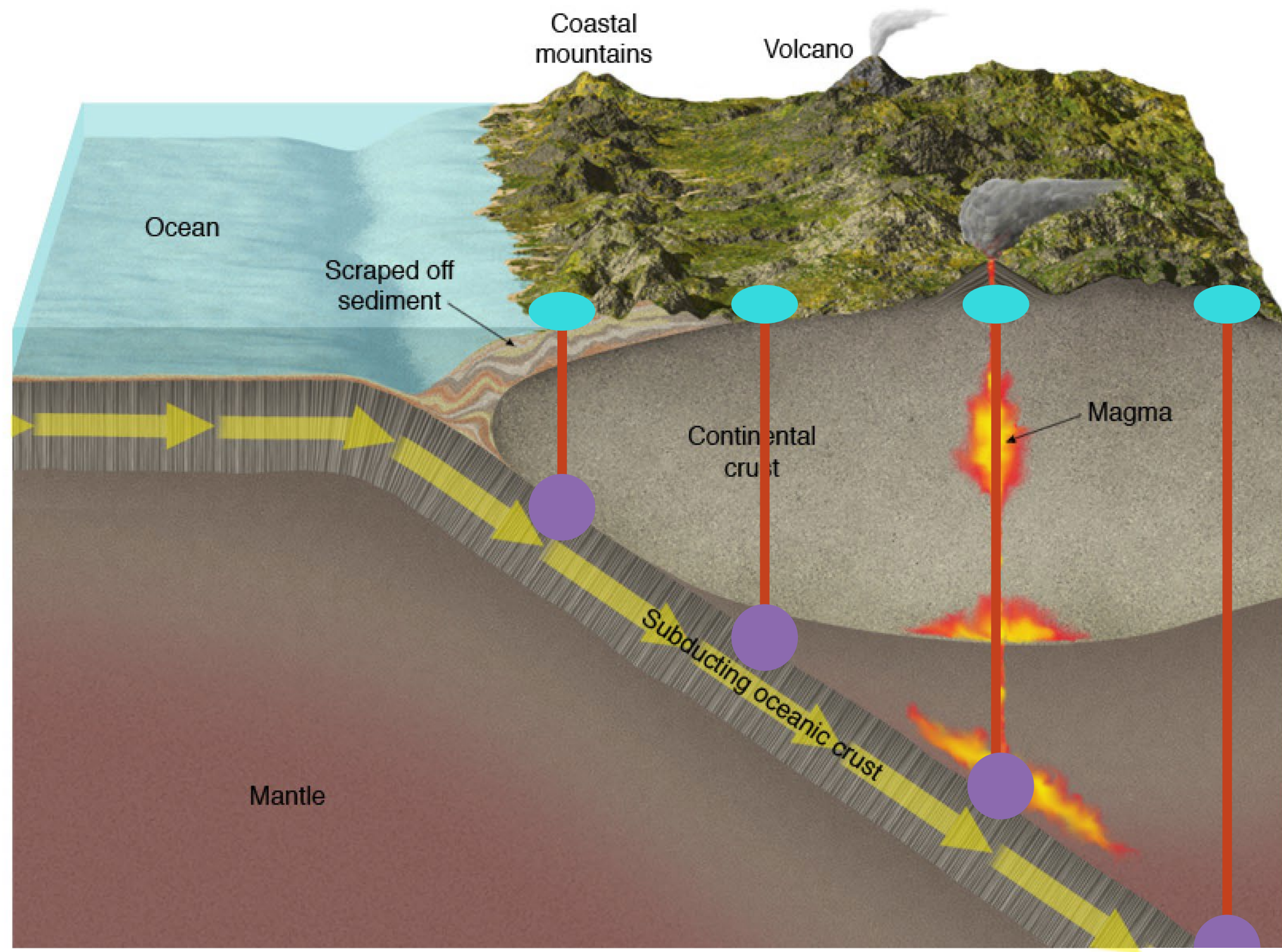
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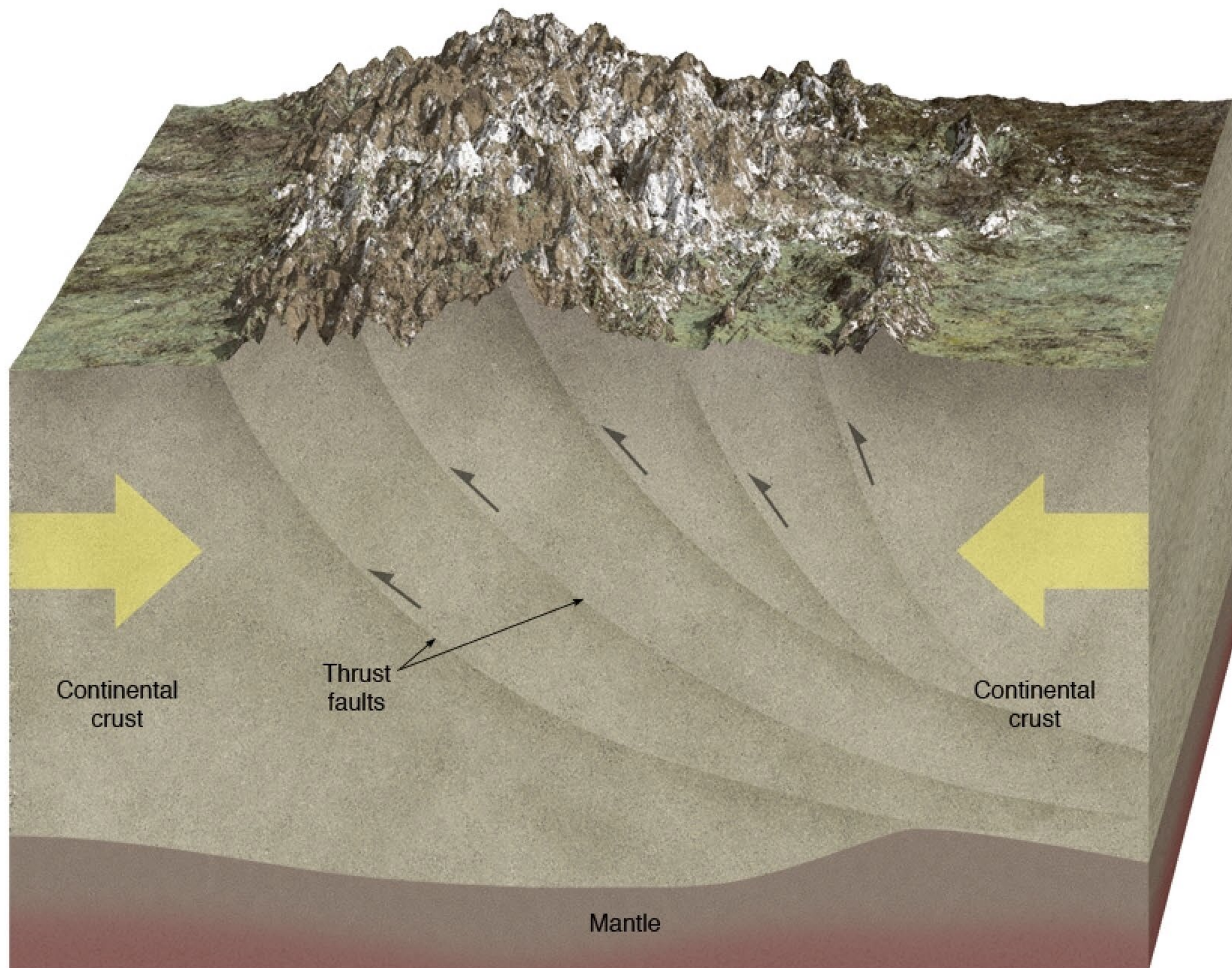
Describing Where An Earthquake Occurs

- **Focus** - the **underground** place where the rock begins to separate.
- **Epicenter** - the location **directly above** the **focus** of an earthquake on the **surface of Earth**.

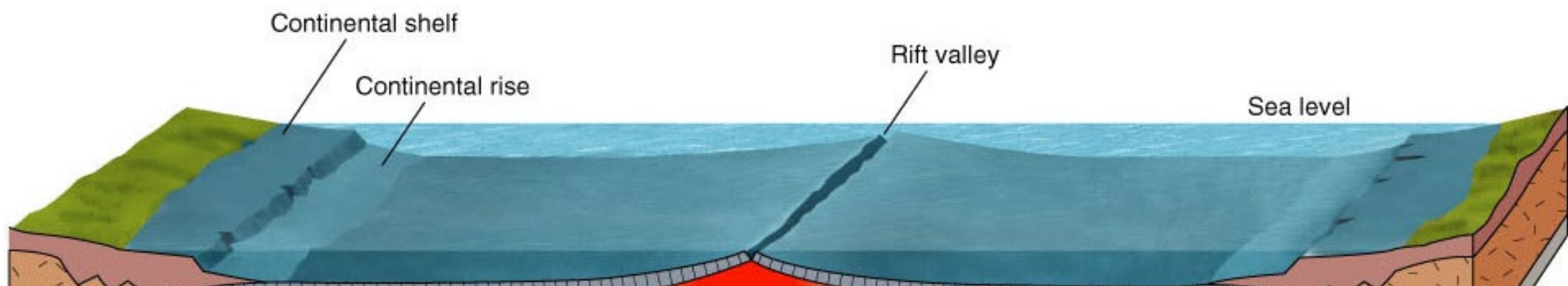
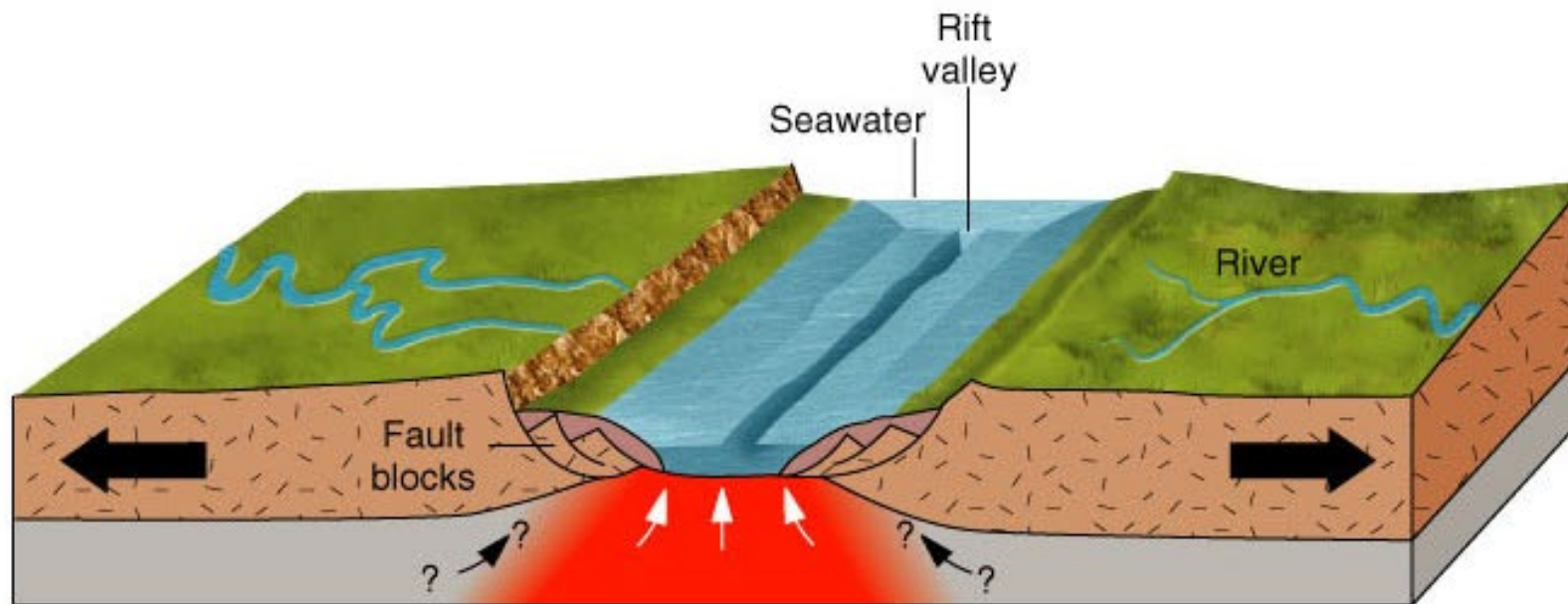
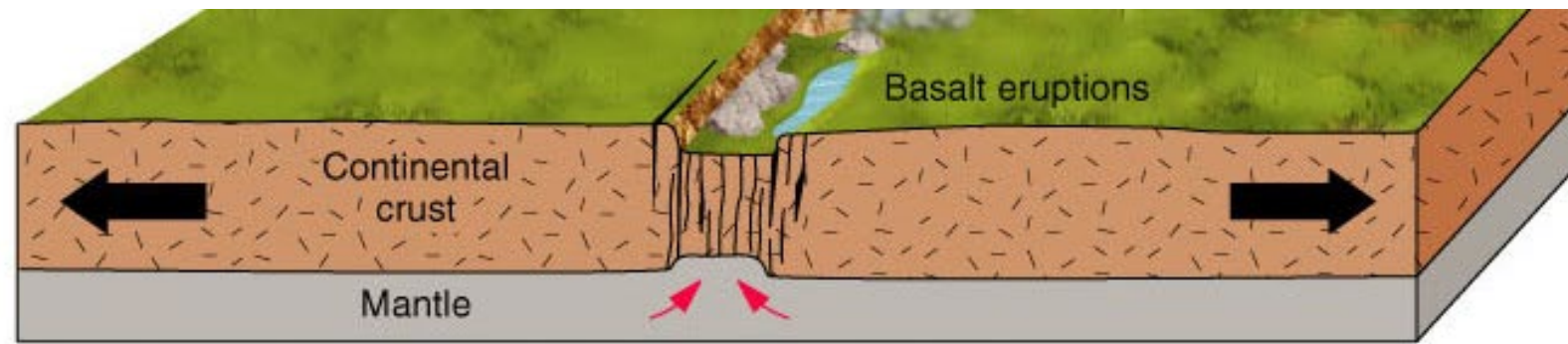
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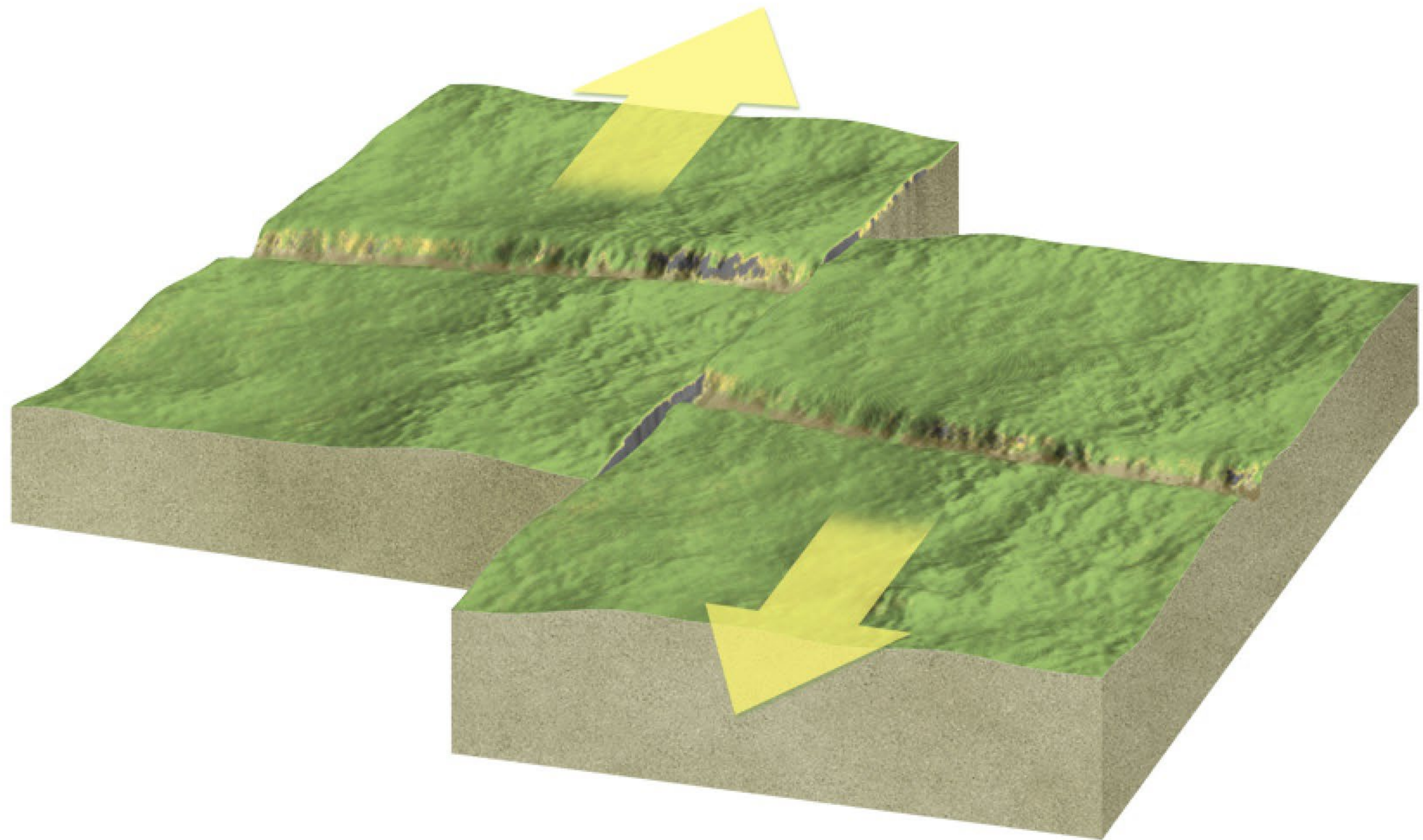
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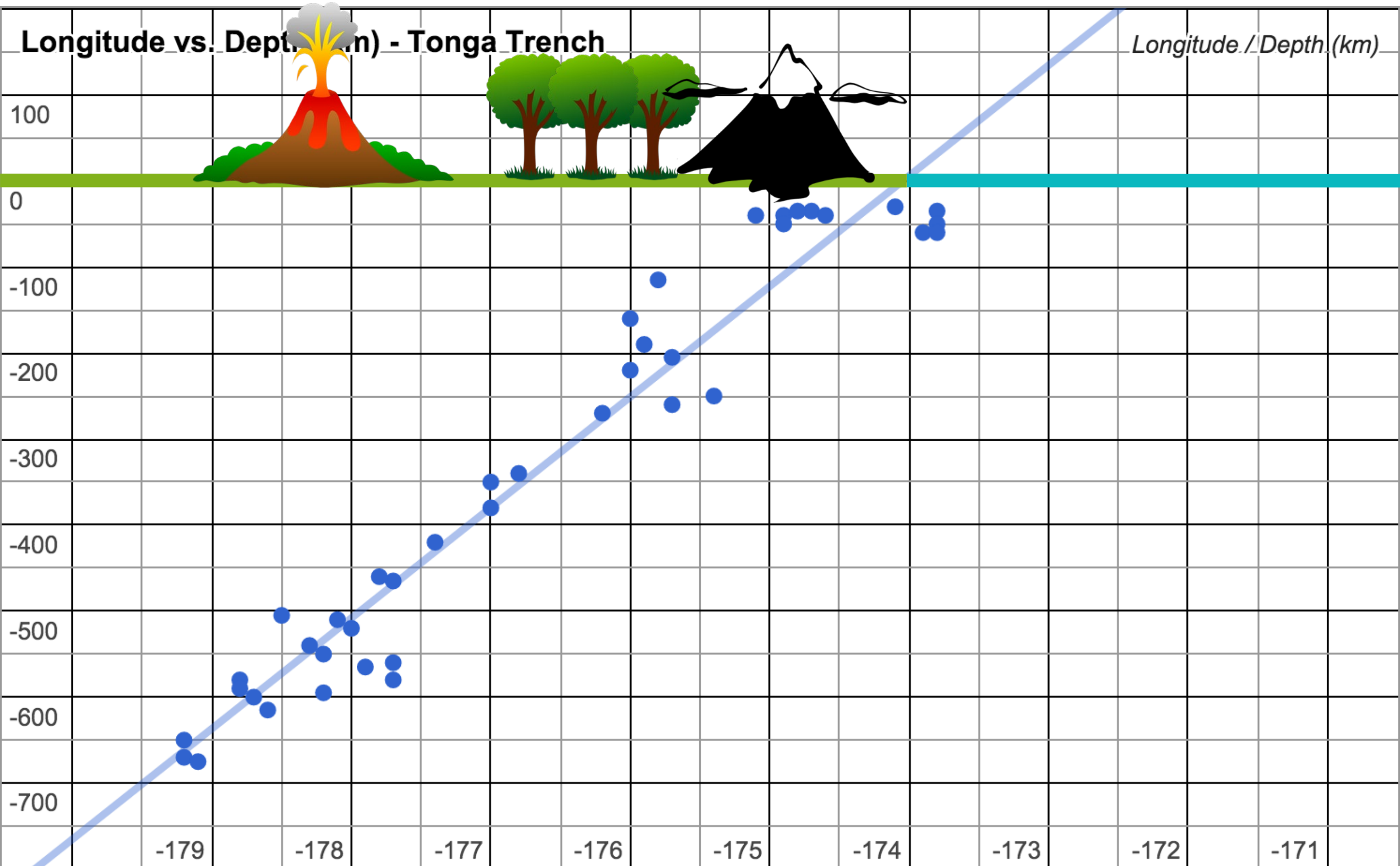
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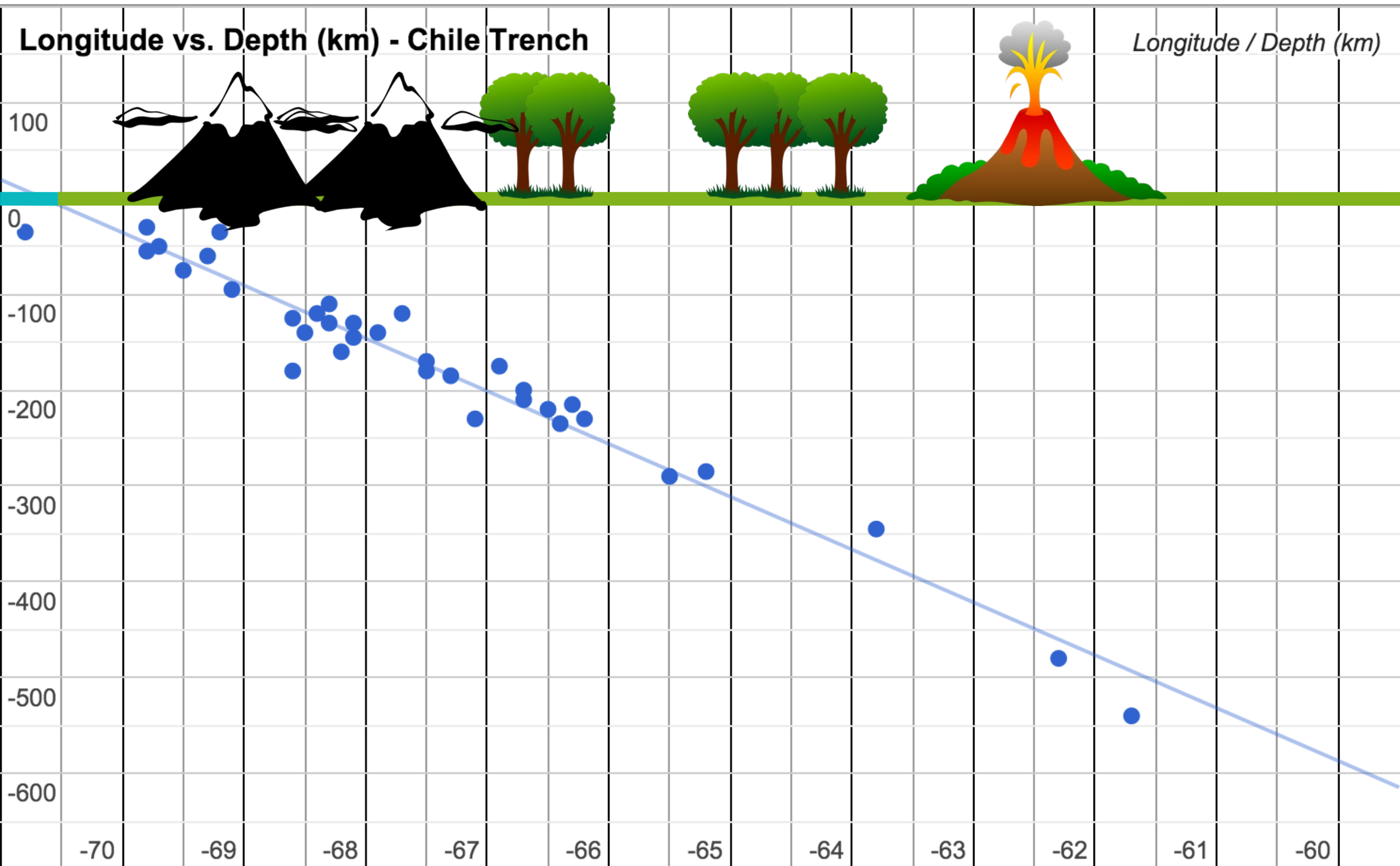
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What do earthquakes cause?

- Building damage.
- Fires when gas lines and electric wires rupture or break.
- **Tsunami** - a giant series of **waves** caused by an earthquake.

27 minutes after Earthquake...

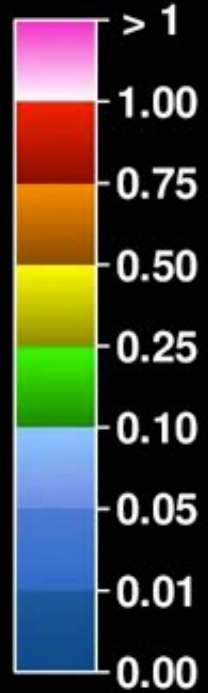
Elapsed
Time:

00 hr
27 min

UTC:

2004
26 Dec
01:25 Z

Tsunami
Wave
Amplitude
(meters)



speed = 180x
or 1 sec = 3 min

5 hours after Earthquake...

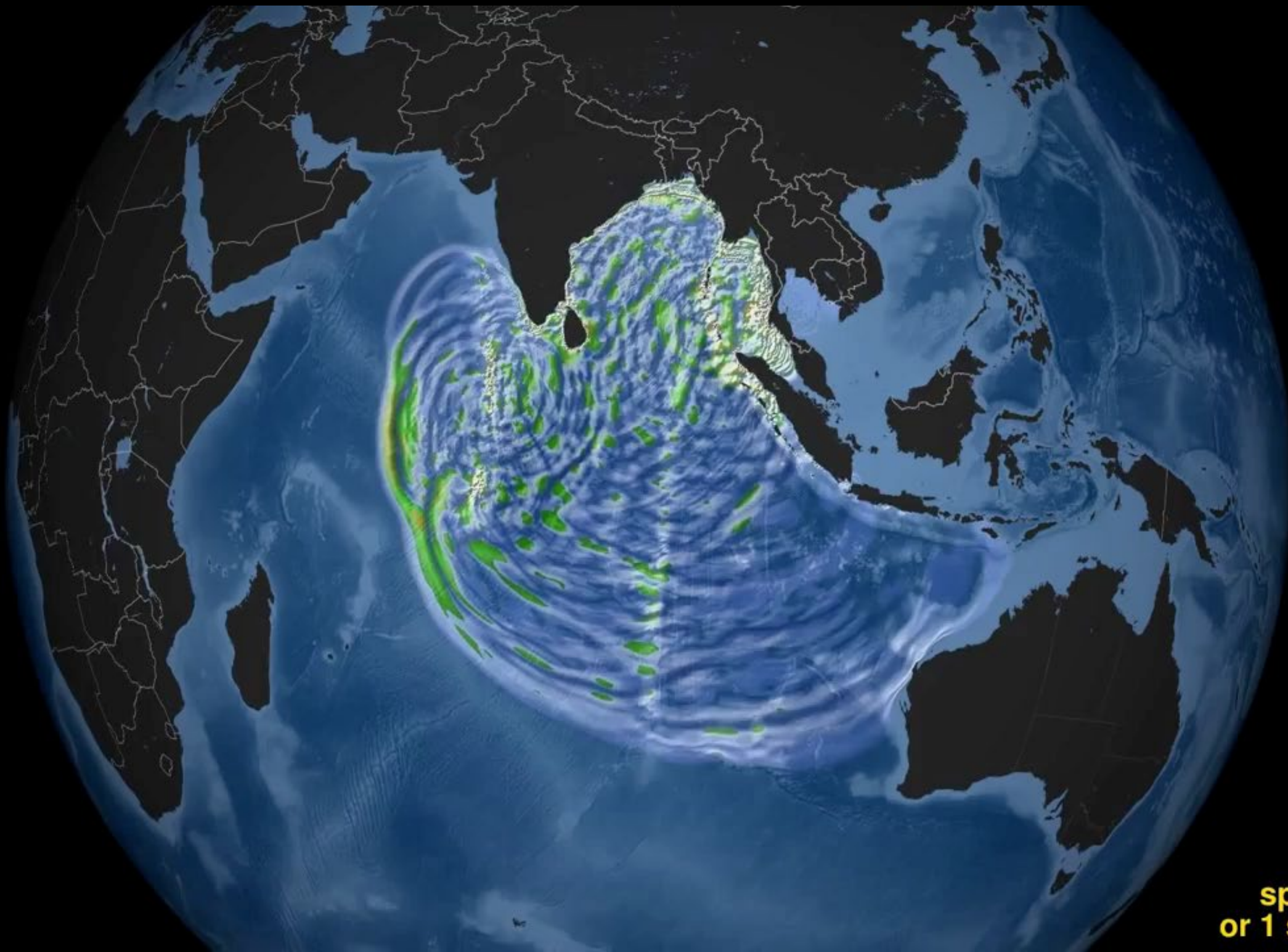
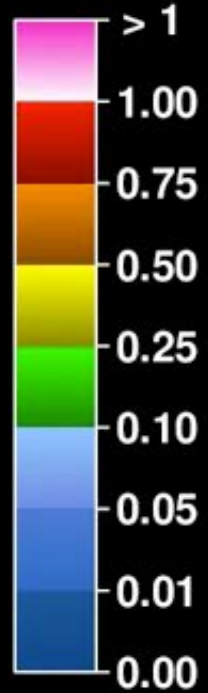
Elapsed
Time:

05 hr
00 min

UTC:

2004
26 Dec
05:59 Z

Tsunami
Wave
Amplitude
(meters)



speed = 1800x
or 1 sec = 30 min

10 hours after Earthquake...

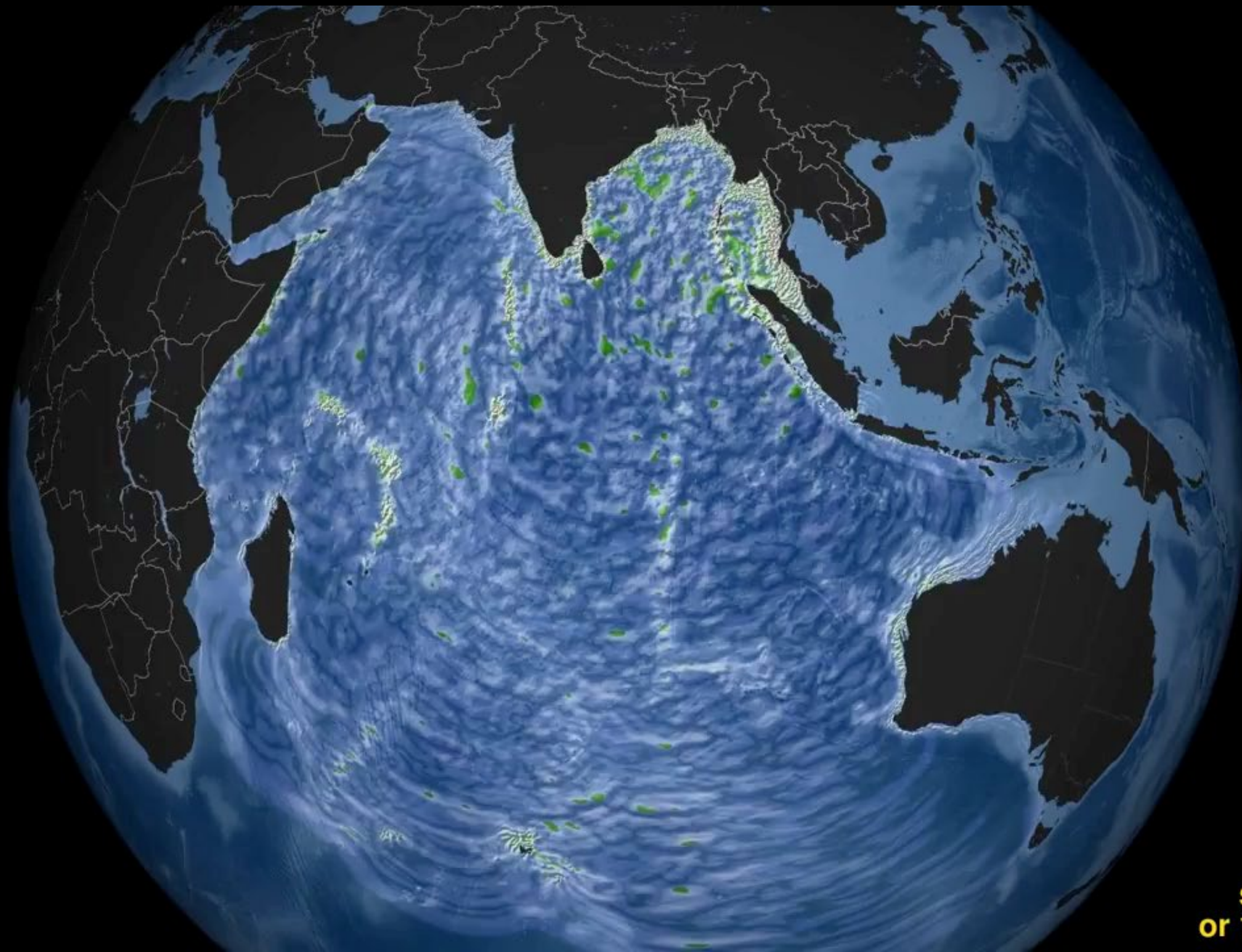
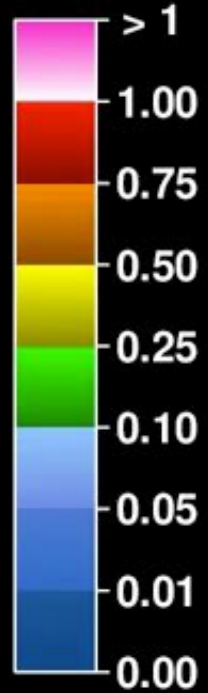
Elapsed
Time:

10 hr
31 min

UTC:

2004
26 Dec
11:29 Z

Tsunami
Wave
Amplitude
(meters)



speed = 1800x
or 1 sec = 30 min

24 hours after Earthquake...

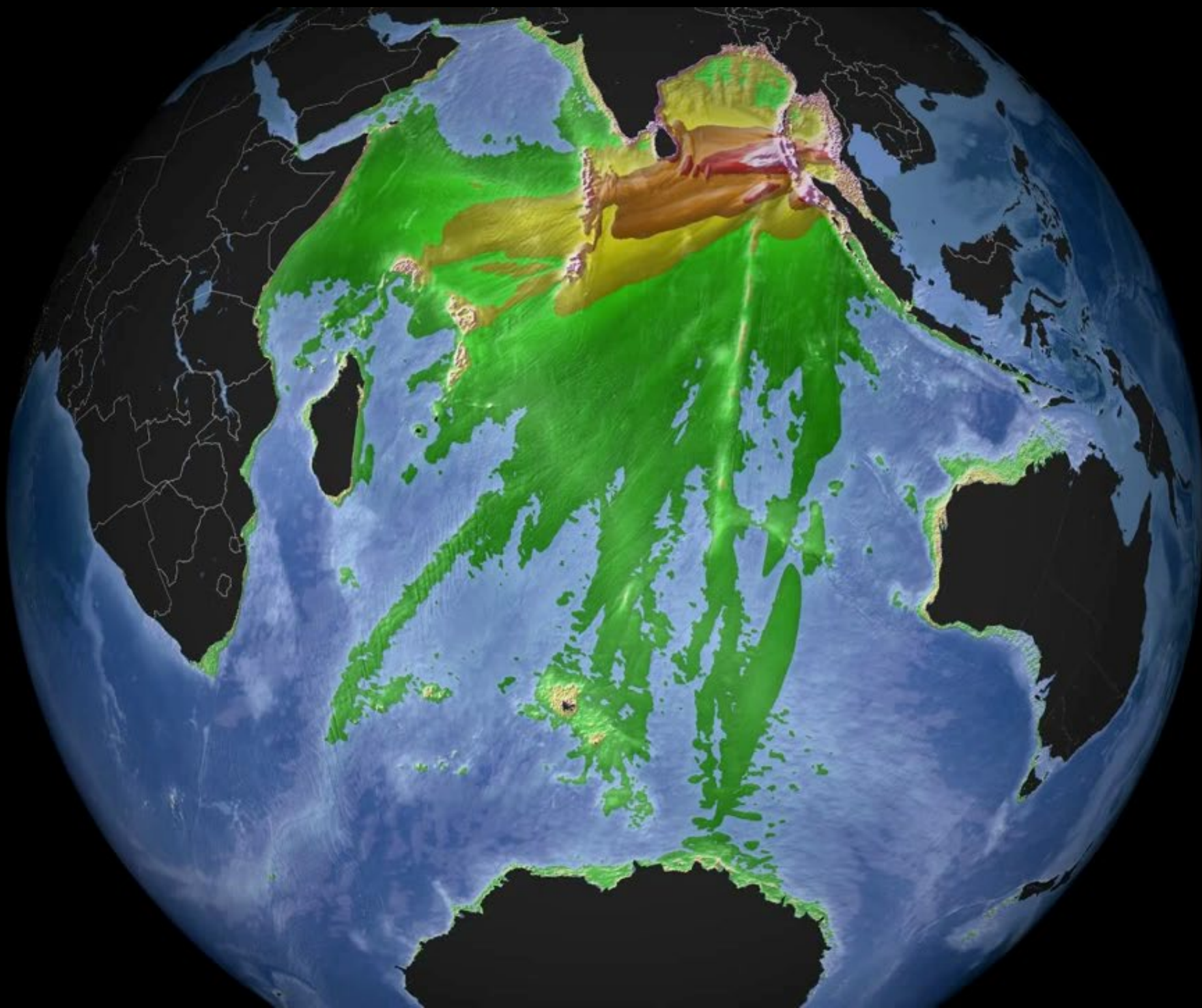
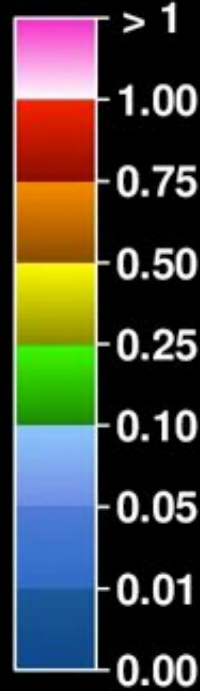
Elapsed
Time:

24 hr
00 min

UTC:

2004
27 Dec
00:58 Z

Tsunami
Wave
Amplitude
(meters)



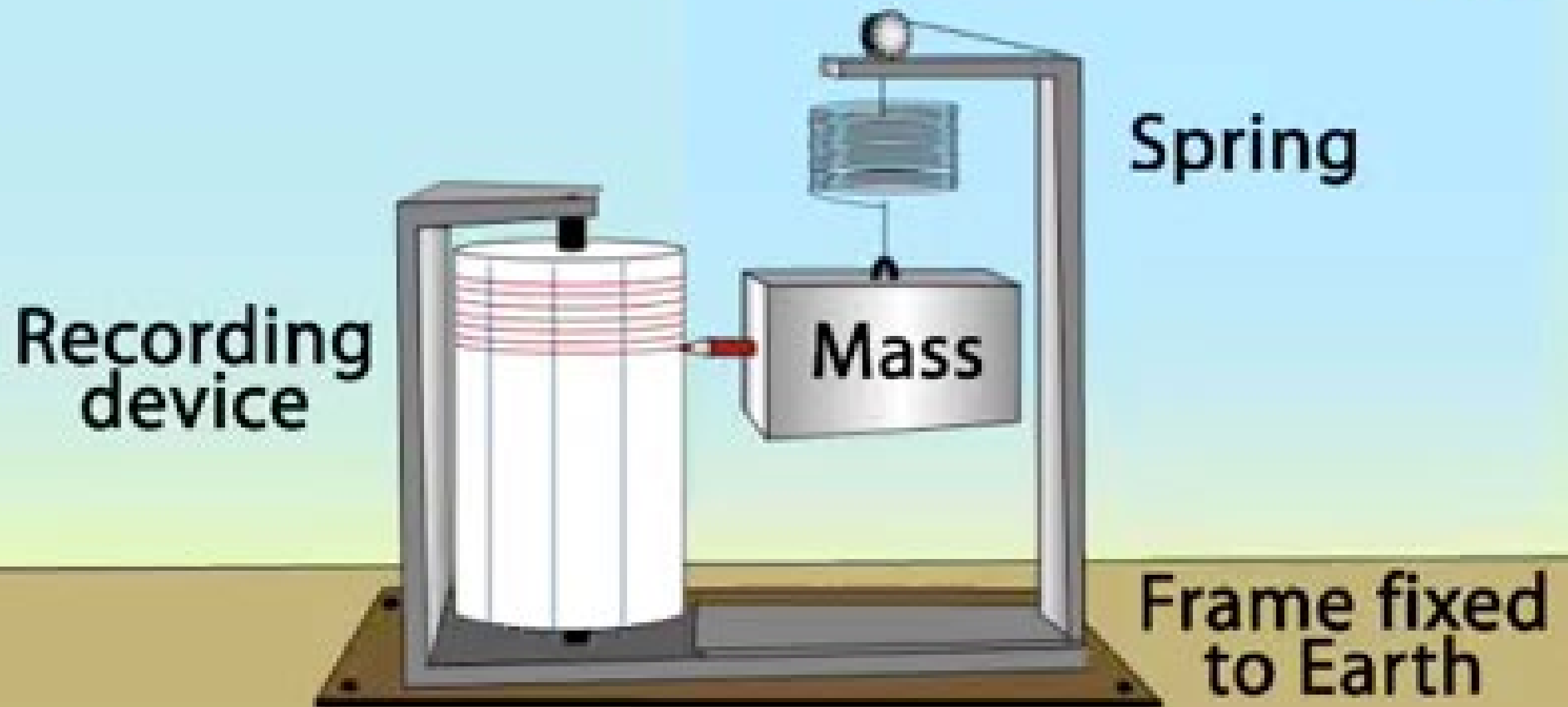


How do we measure earthquakes?

- Scientists measure the **magnitude of earthquakes** using **seismographs**. The Richter Scale is the most common earthquake measurement.
- Using this data, scientists can **locate** the **epicenter** and **focus** of an earthquake.

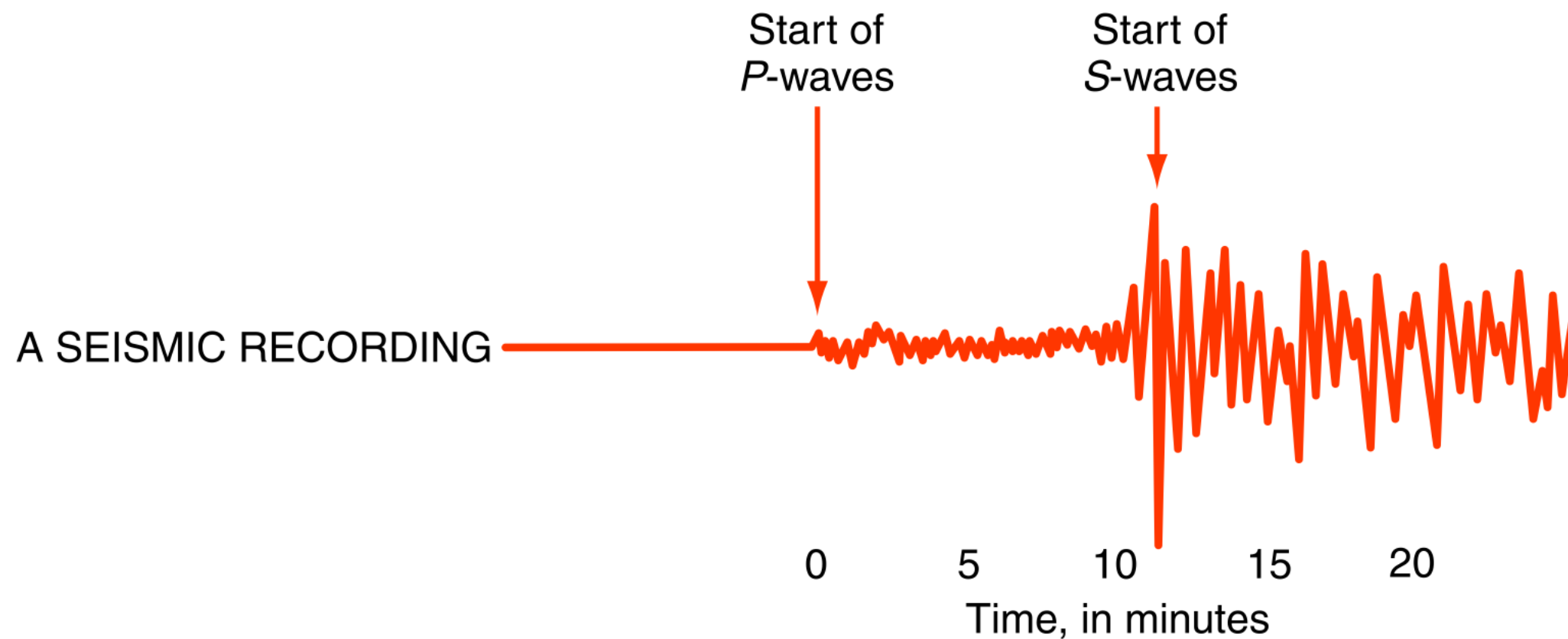
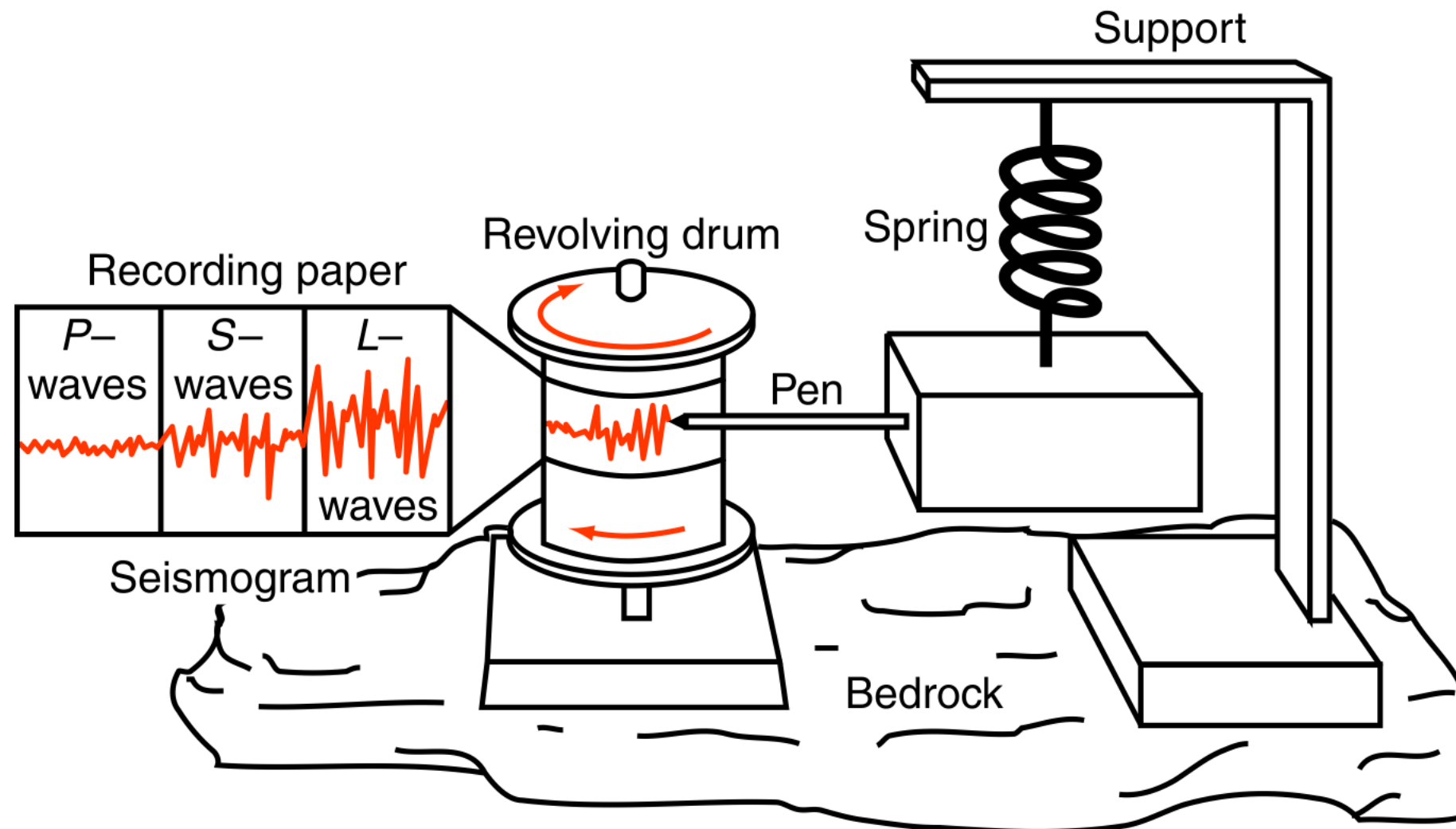
Goal: Students will be able to describe where an earthquake occurs.

scope

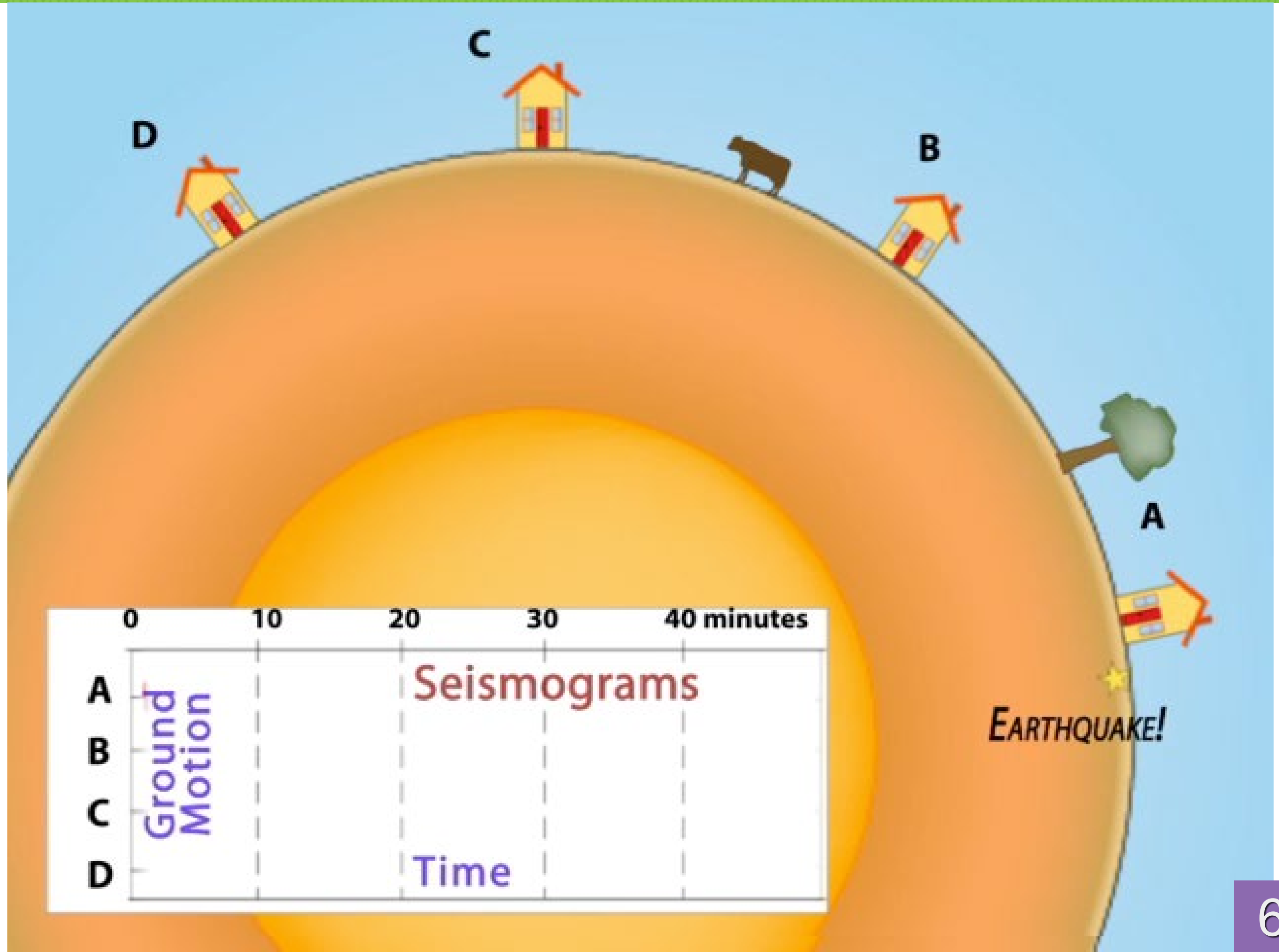


Vertical Seismograph
with generalized
P- and S-wave behavior

Goal: Students will be able to describe where an earthquake occurs.



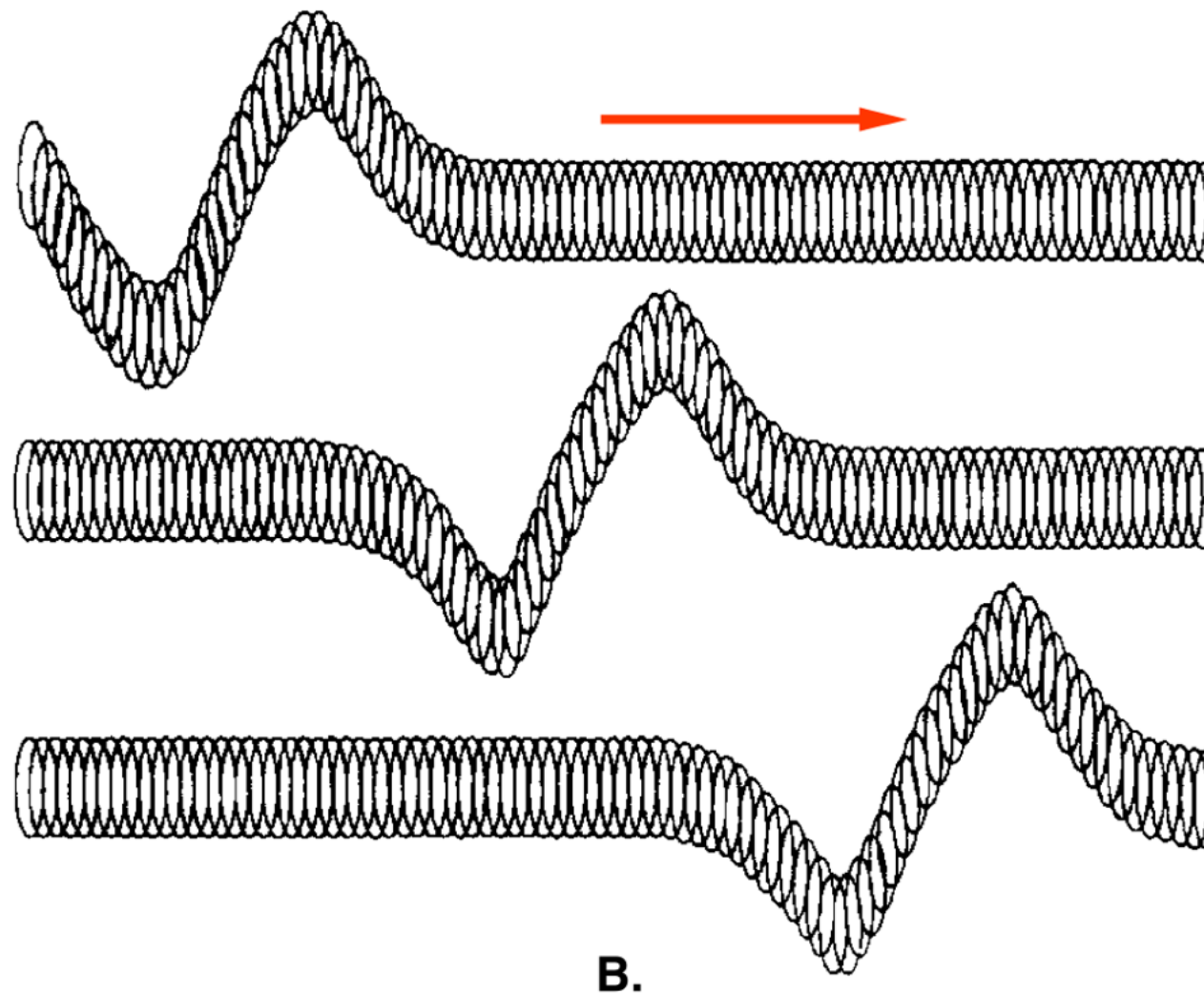
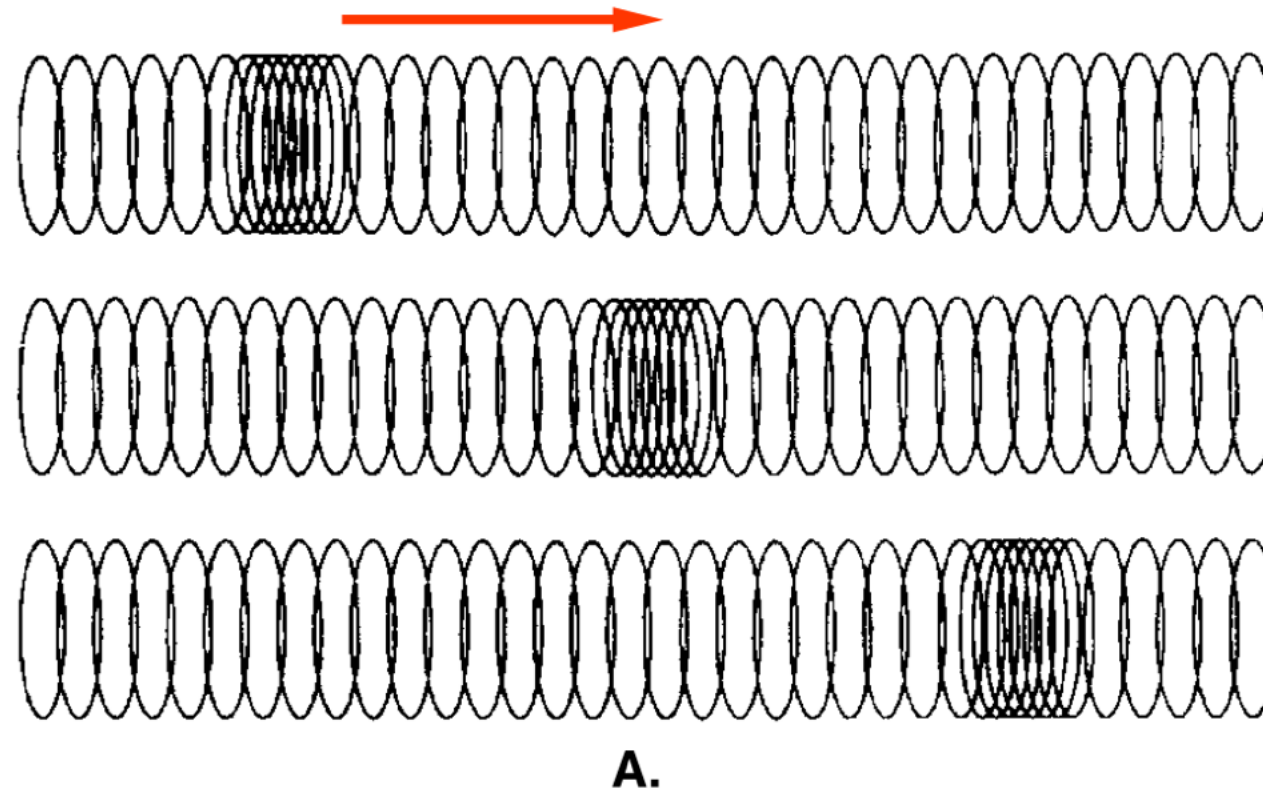
Goal: Students will be able to describe where an earthquake occurs.



When earthquakes occur, three types of waves are released from the focus.

- **P-wave (Primary wave)** - travel the **fastest**, arrive **first**, and can travel through any material—**solid, liquid, or gas**.
- **S-wave** - travel at roughly **half the speed** of **P-waves**, arrive **second**, and can travel through a rigid medium (**solids**), but cannot pass through a fluid, which includes liquids or gases.
- **Surface waves** - when **P-waves** and **S-waves** reach the surface, they are transformed into **surface waves**, which cause the **most damage**.

Goal: Students will be able to describe where an earthquake occurs.



P waves

particle motion parallel
to wave motion



direction of wave motion

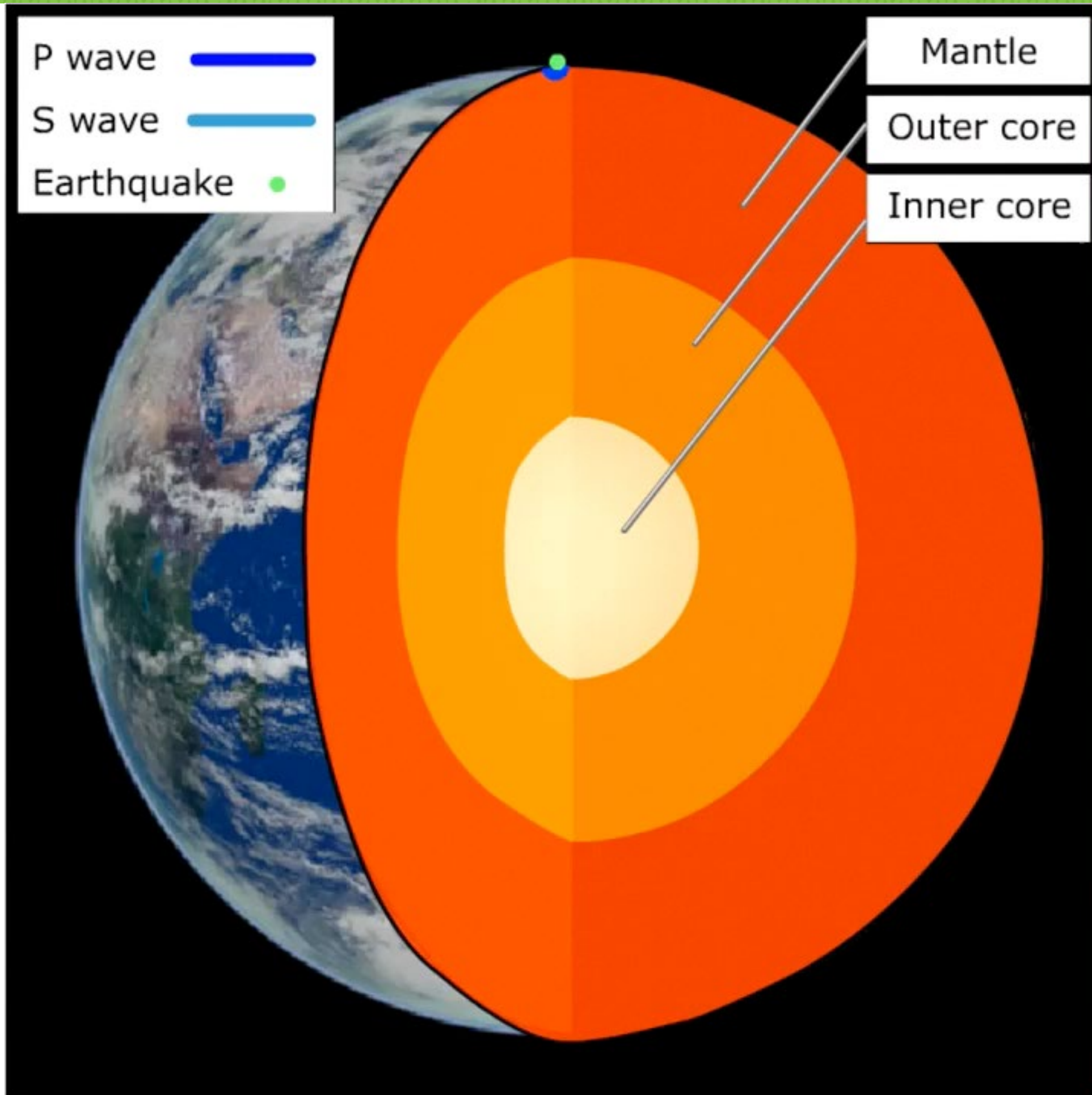
S waves

particle motion perpendicular
to wave motion



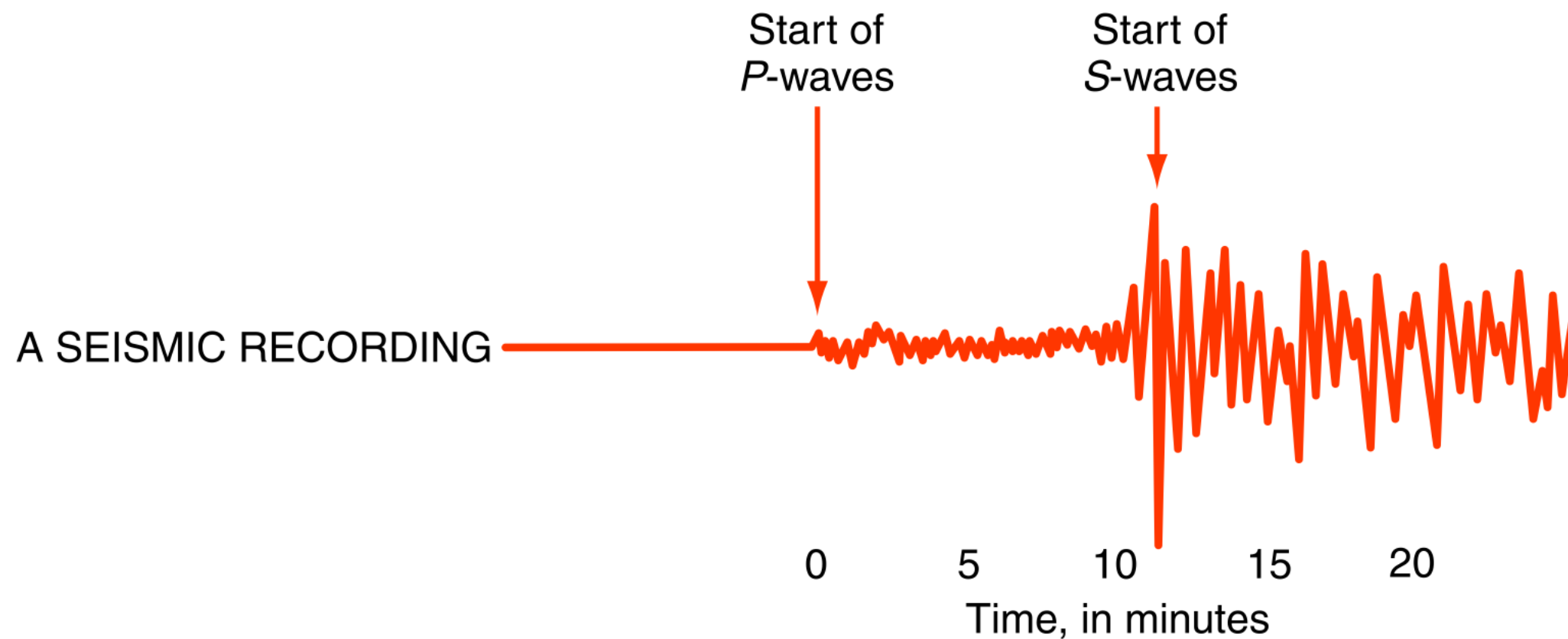
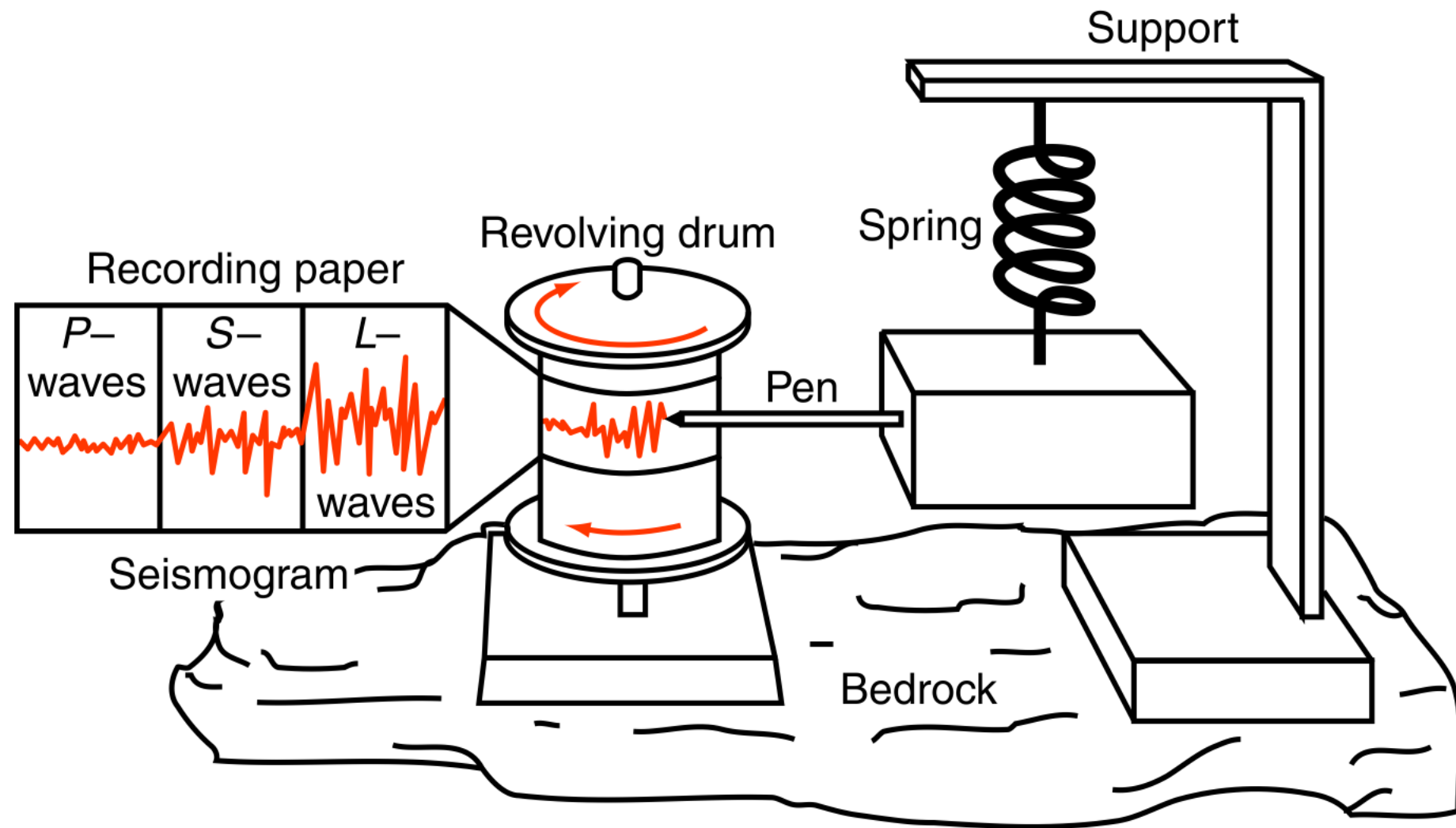
direction of wave motion

Goal: Students will be able to describe where an earthquake occurs.

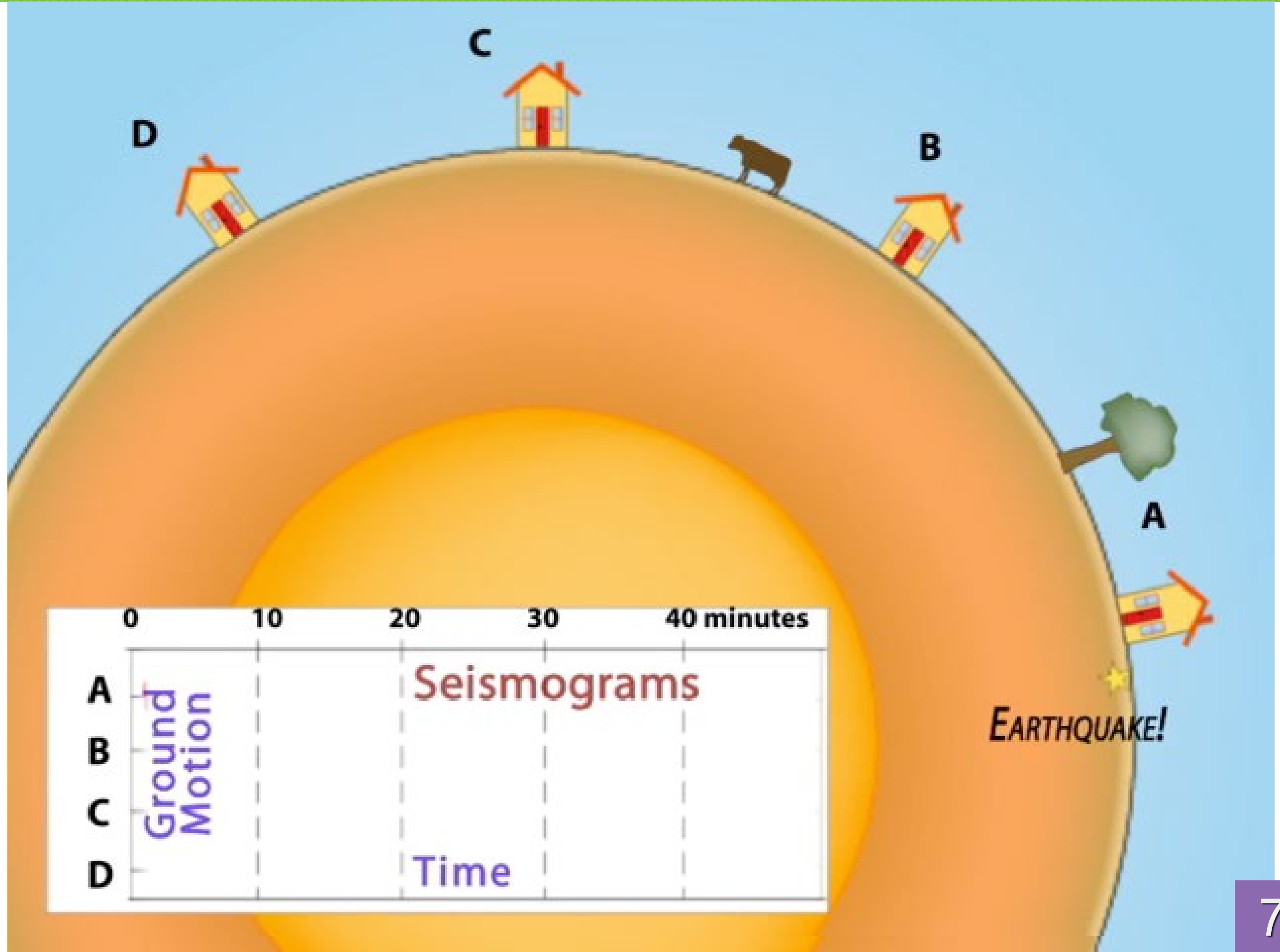


How do scientists figure out where earthquakes occur?

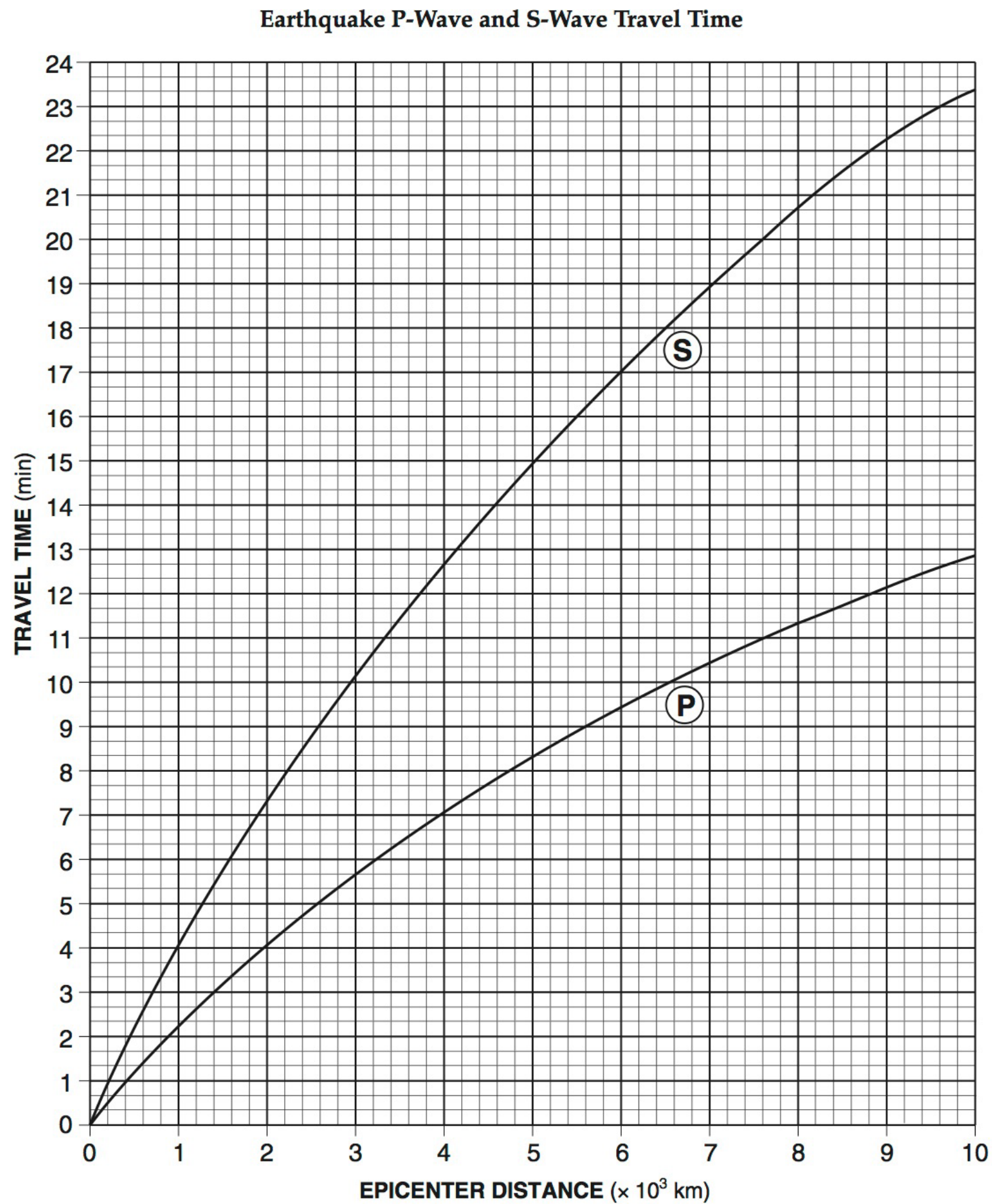
Goal: Students will be able to describe where an earthquake occurs.



Goal: Students will be able to describe where an earthquake occurs.



Goal: Students will be able to use the “Earthquake P-Wave and S-Wave Travel Time” graph to find the epicenter of an earthquake.



Goal: Students will be able to use the “Earthquake P-Wave and S-Wave Travel Time” graph to find the epicenter of an earthquake.

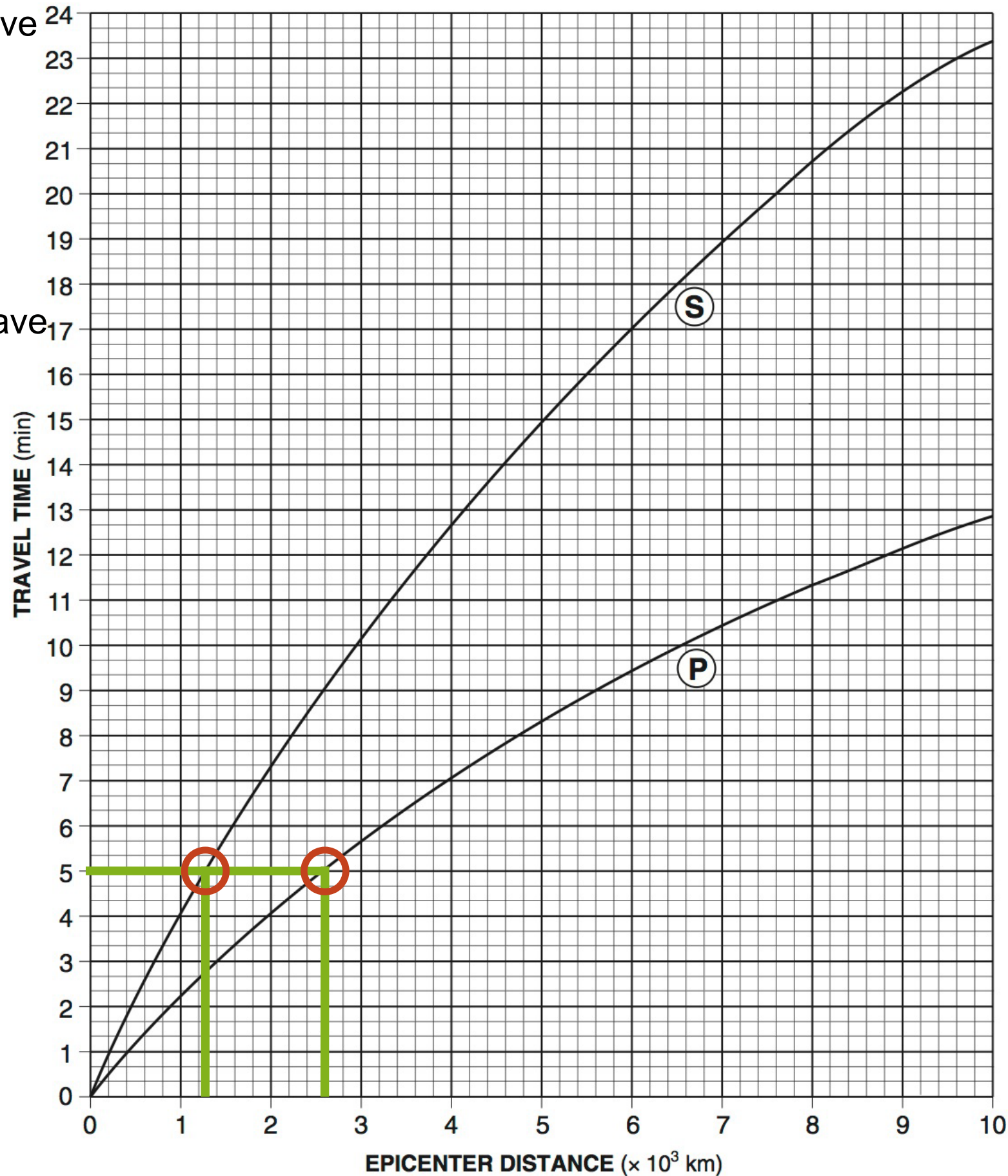
Earthquake P-Wave and S-Wave Travel Time

How far would a P-wave travel in 5 minutes?

$2.6 \times 10^3 \text{ km}$
2,600 km

How far would an S-wave travel in 5 minutes?

$1.2 \times 10^3 \text{ km}$
1,200 km



Goal: Students will be able to use the “Earthquake P-Wave and S-Wave Travel Time” graph to find the epicenter of an earthquake.

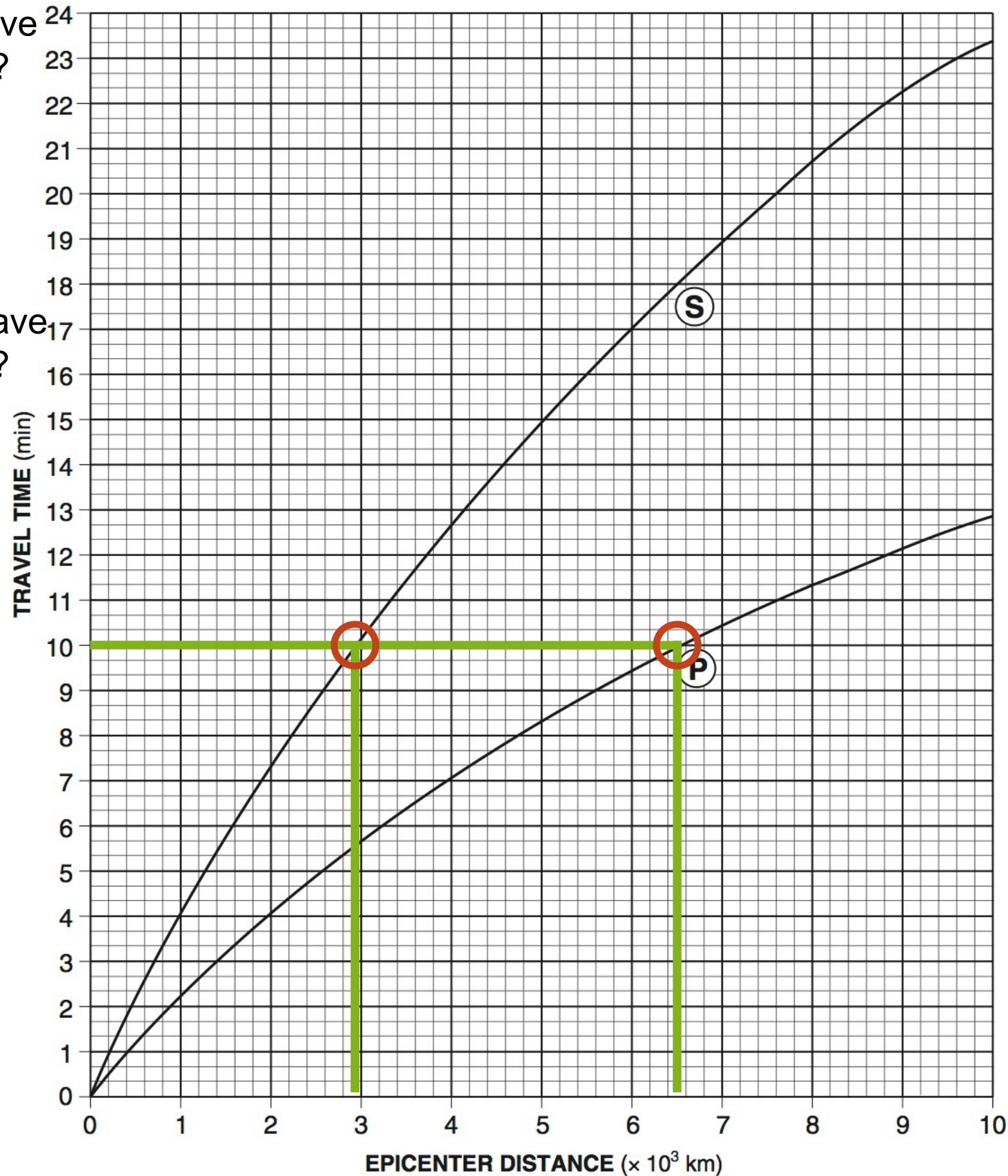
Earthquake P-Wave and S-Wave Travel Time

How far would a P-wave travel in 10 minutes?

$6.5 \times 10^3 \text{ km}$
6,500 km

How far would an S-wave travel in 10 minutes?

$2.95 \times 10^3 \text{ km}$
2,950 km



Goal: Students will be able to use the “Earthquake P-Wave and S-Wave Travel Time” graph to find the epicenter of an earthquake.

How long would it take a P-wave to travel 4,400 km?

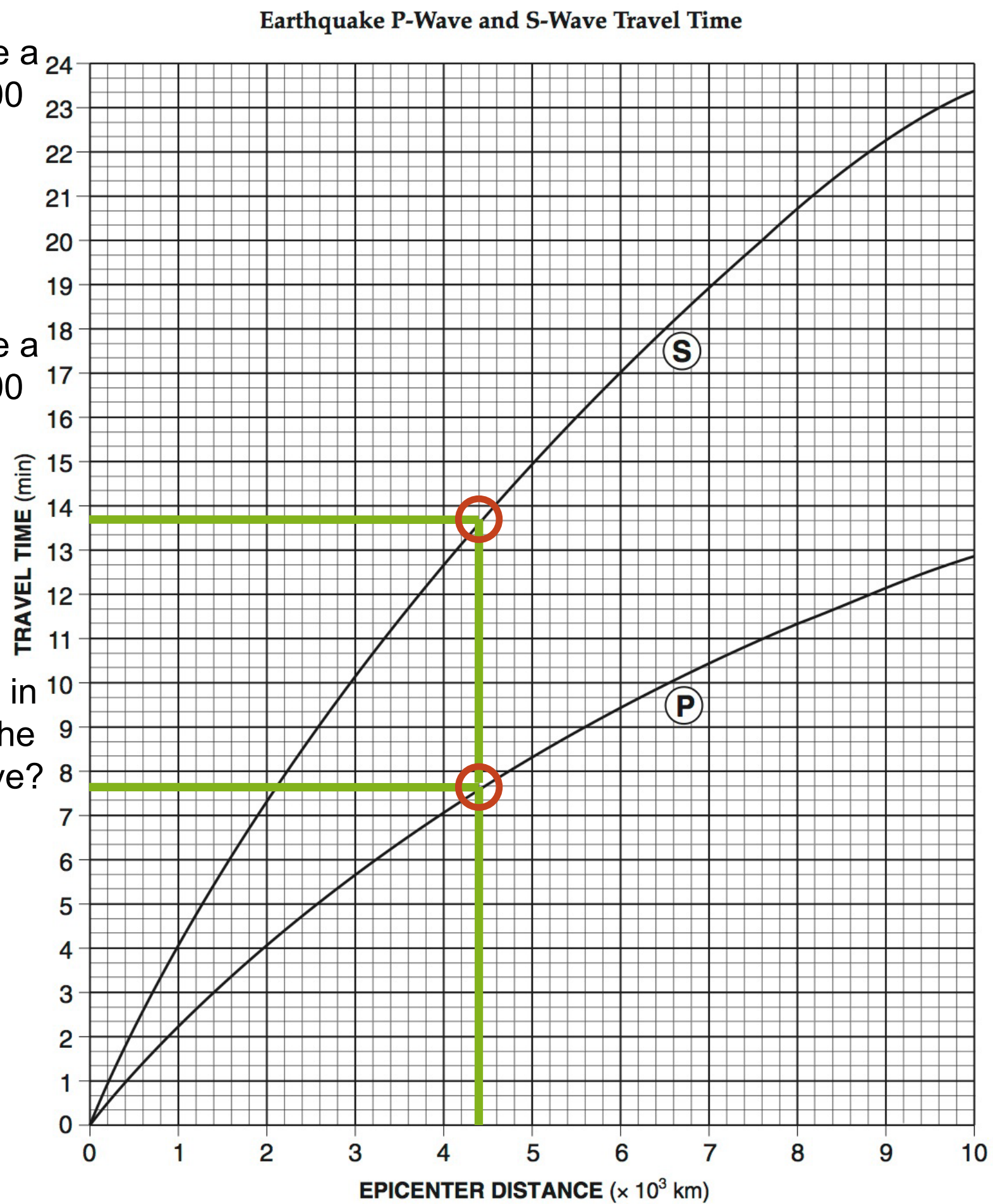
7 min. 40 sec.

How long would it take a S-wave to travel 4,400 km?

13 min. 40 sec.

What is the difference in arrival time between the P-wave and the S-wave?

6 min.



Goal: Students will be able to use the “Earthquake P-Wave and S-Wave Travel Time” graph to find the epicenter of an earthquake.

Earthquake P-Wave and S-Wave Travel Time

How long would it take a P-wave to travel 8,500 km?

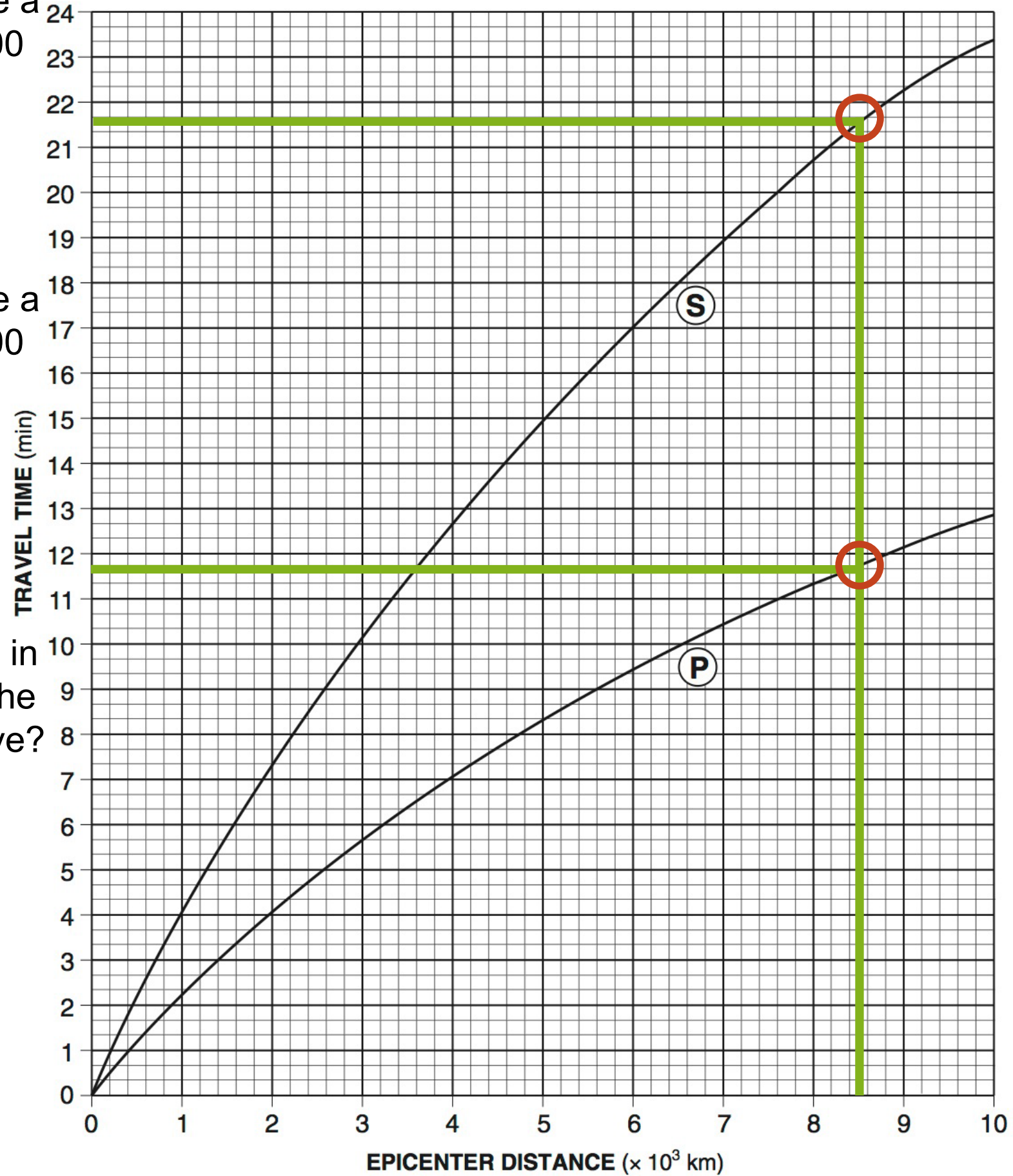
11 min. 40 sec.

How long would it take a S-wave to travel 8,500 km?

21 min. 40 sec.

What is the difference in arrival time between the P-wave and the S-wave?

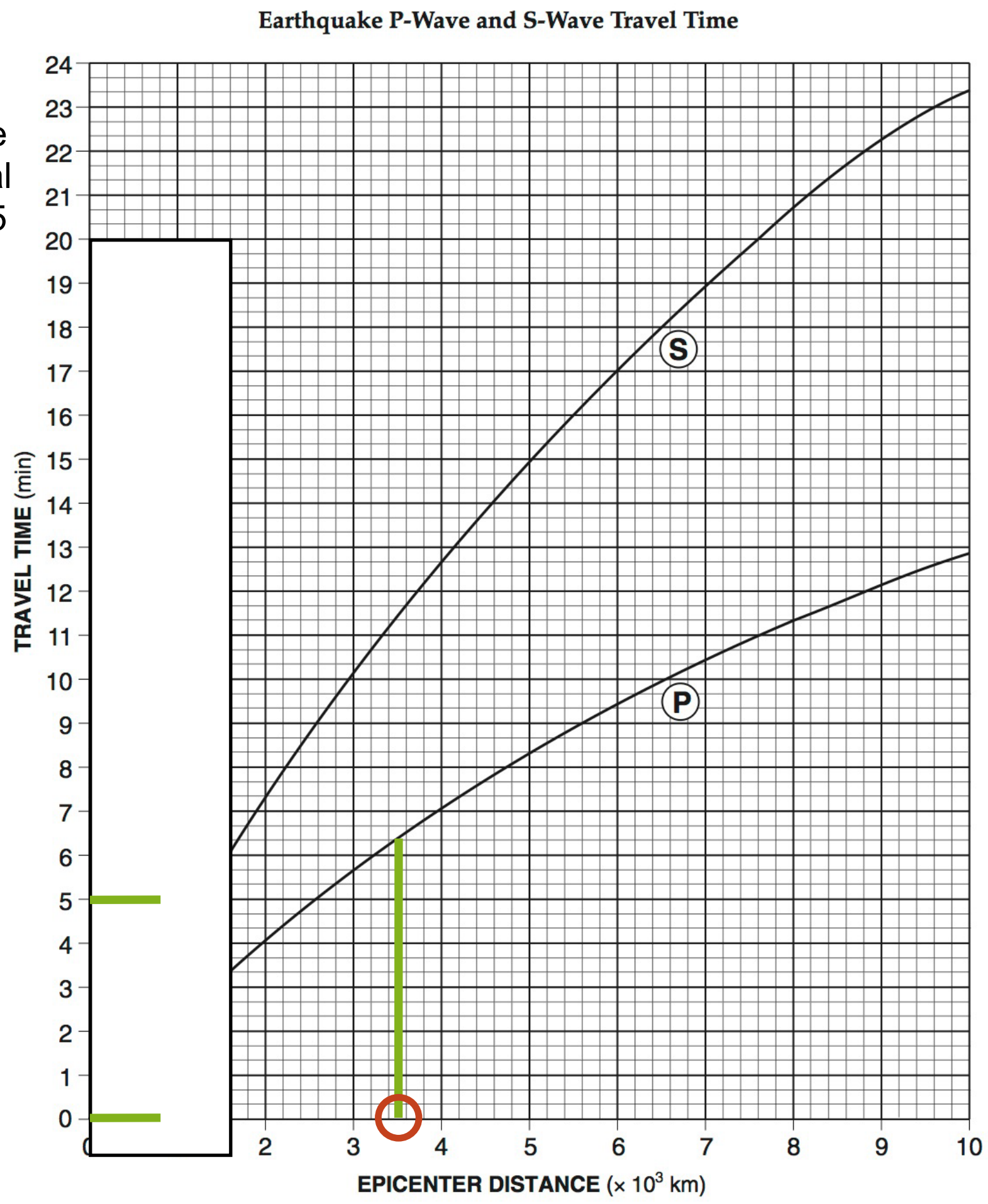
10 min.



Goal: Students will be able to use the “Earthquake P-Wave and S-Wave Travel Time” graph to find the epicenter of an earthquake.

If the difference in time between P-wave arrival and S-wave arrival is 5 minutes, what is the distance to the epicenter?

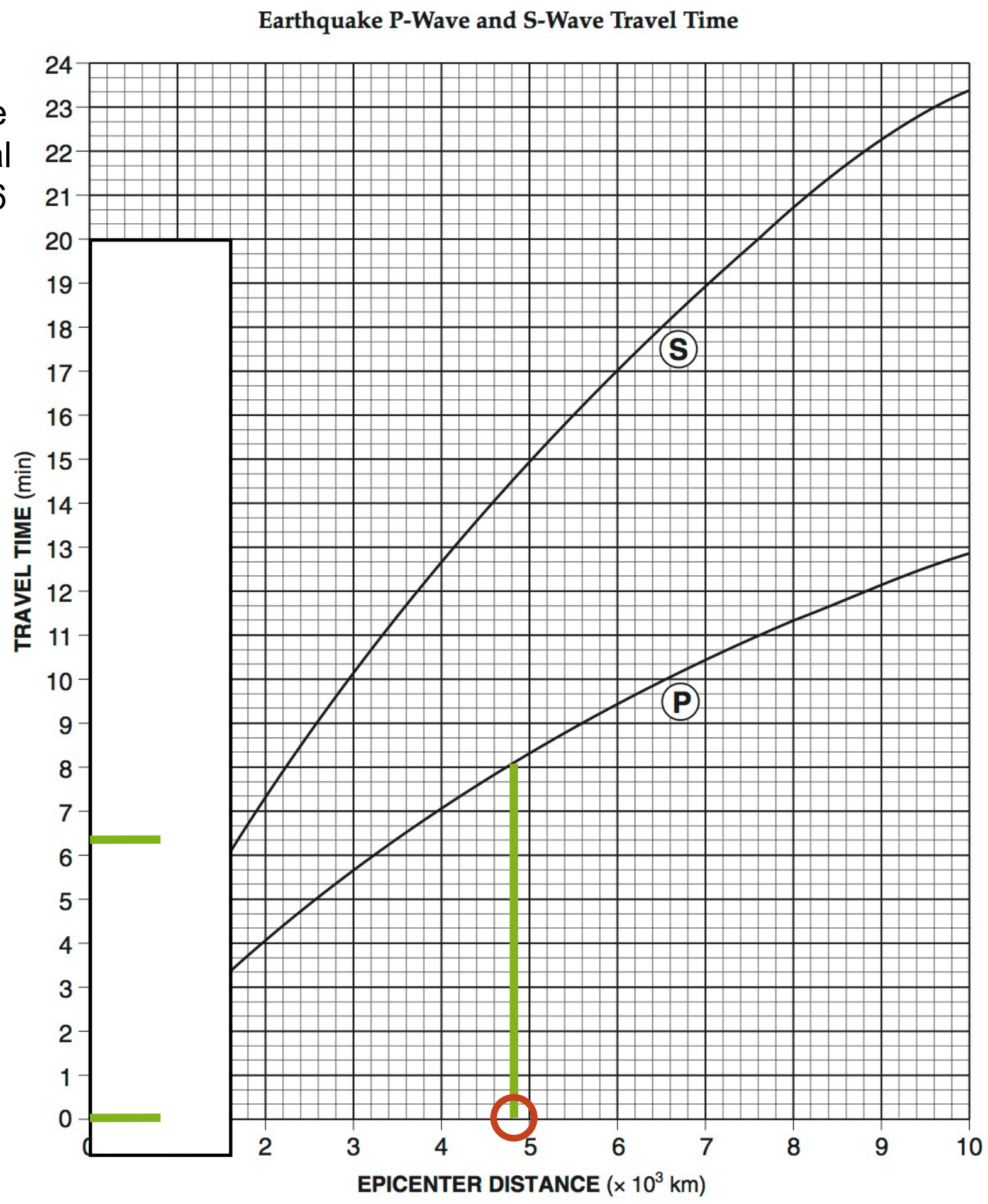
$3.5 \times 10^3 \text{ km}$
3,500 km



Goal: Students will be able to use the “Earthquake P-Wave and S-Wave Travel Time” graph to find the epicenter of an earthquake.

If the difference in time between P-wave arrival and S-wave arrival is 6 minutes and 20 seconds, what is the distance to the epicenter?

4.8 X 10³ km
4,800 km



Goal: Students will be able to use earthquake data to find the epicenter of an earthquake.



An earthquake occurred...

- 600 km from Jefferson City
- 725 km from Salt Lake City
- 650 km from Tallahassee

The epicenter was here.

Map Scale



Goal: Students will be able to use earthquake data to find the epicenter of an earthquake.



The map shows the United States with state boundaries as dashed lines and major cities as dots. Three red circles represent the distances from three cities to the earthquake epicenter. A purple arrow points to the intersection of these circles, which is the epicenter. The cities involved are Sacramento, Bismarck, and Santa Fe. The epicenter is located in the northern part of California, near the border with Oregon and Idaho.

The epicenter was here.

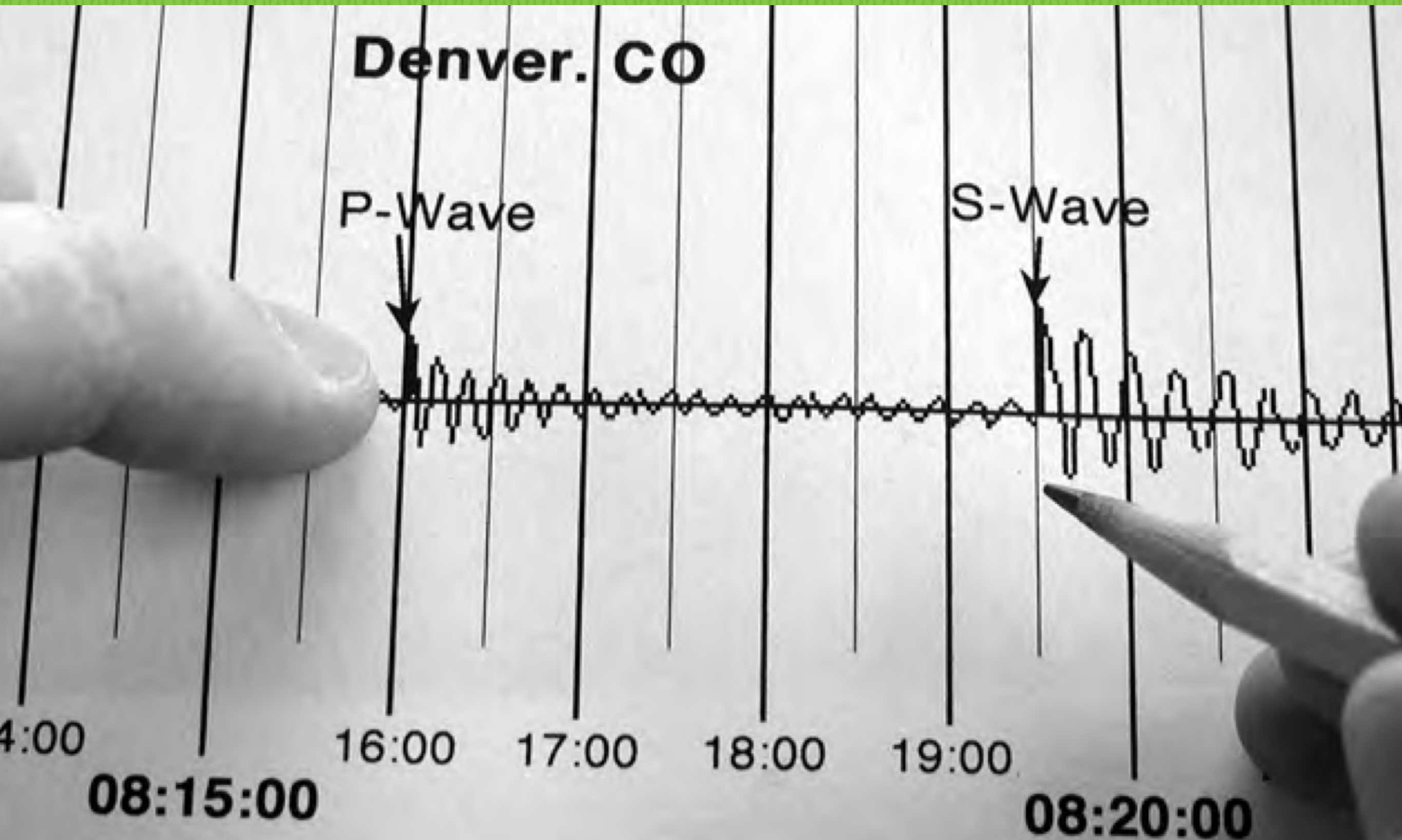
An earthquake occurred...

- 550 km from Sacramento
- 450 km from Bismarck
- 675 km from Santa Fe

Map Scale



Goal: Students will be able to describe where an earthquake occurs.



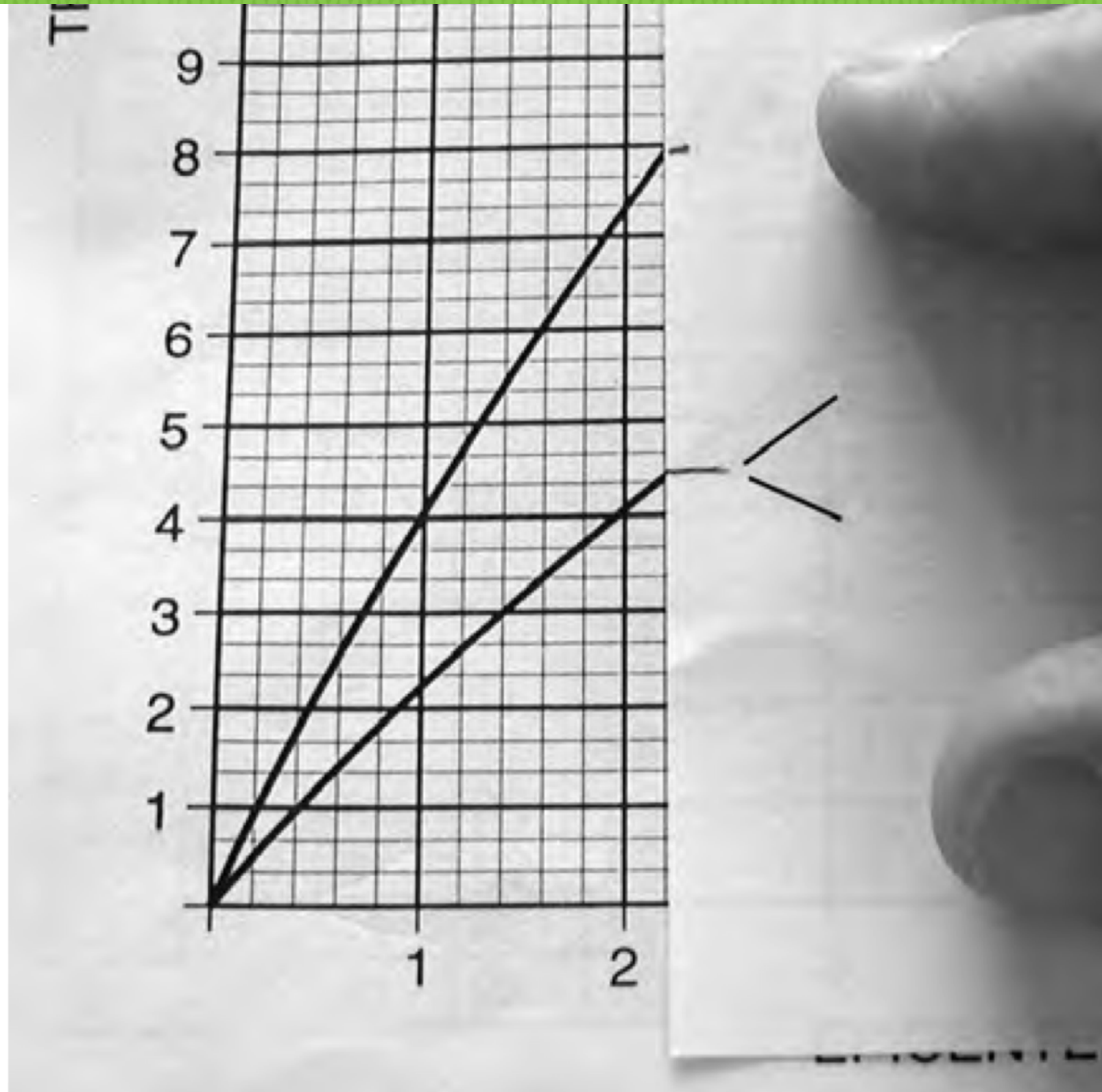
1. Find difference in time between P-wave and S-wave arrival time.

Goal: Students will be able to describe where an earthquake occurs.



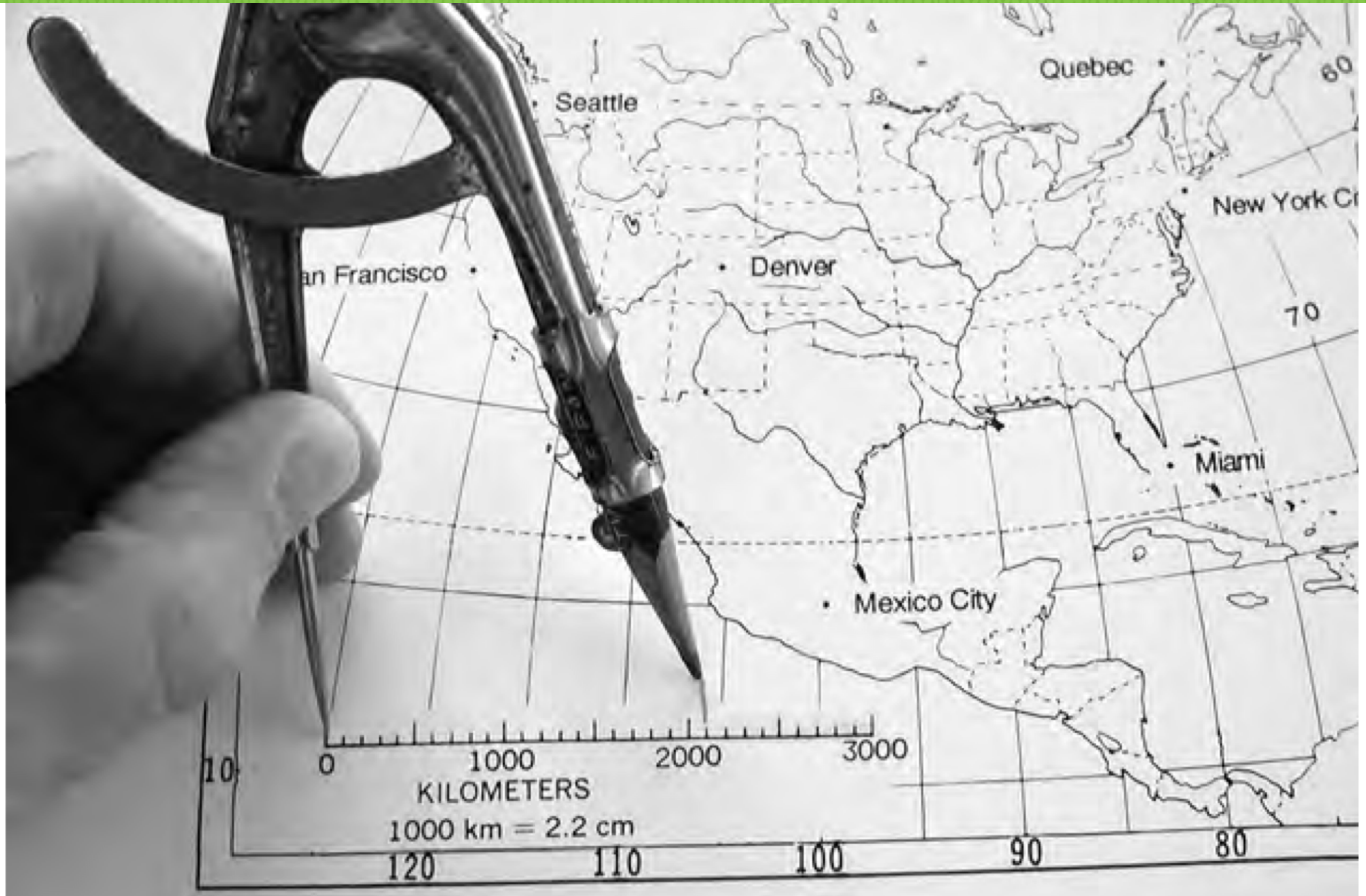
2. Measure that time difference on the Earthquake graph (Y-axis). Place one mark at 0, another at the time difference.

Goal: Students will be able to describe where an earthquake occurs.



3. Move these markers to the right until they line up with both lines. Look straight down to find epicenter distance.

Goal: Students will be able to describe where an earthquake occurs.



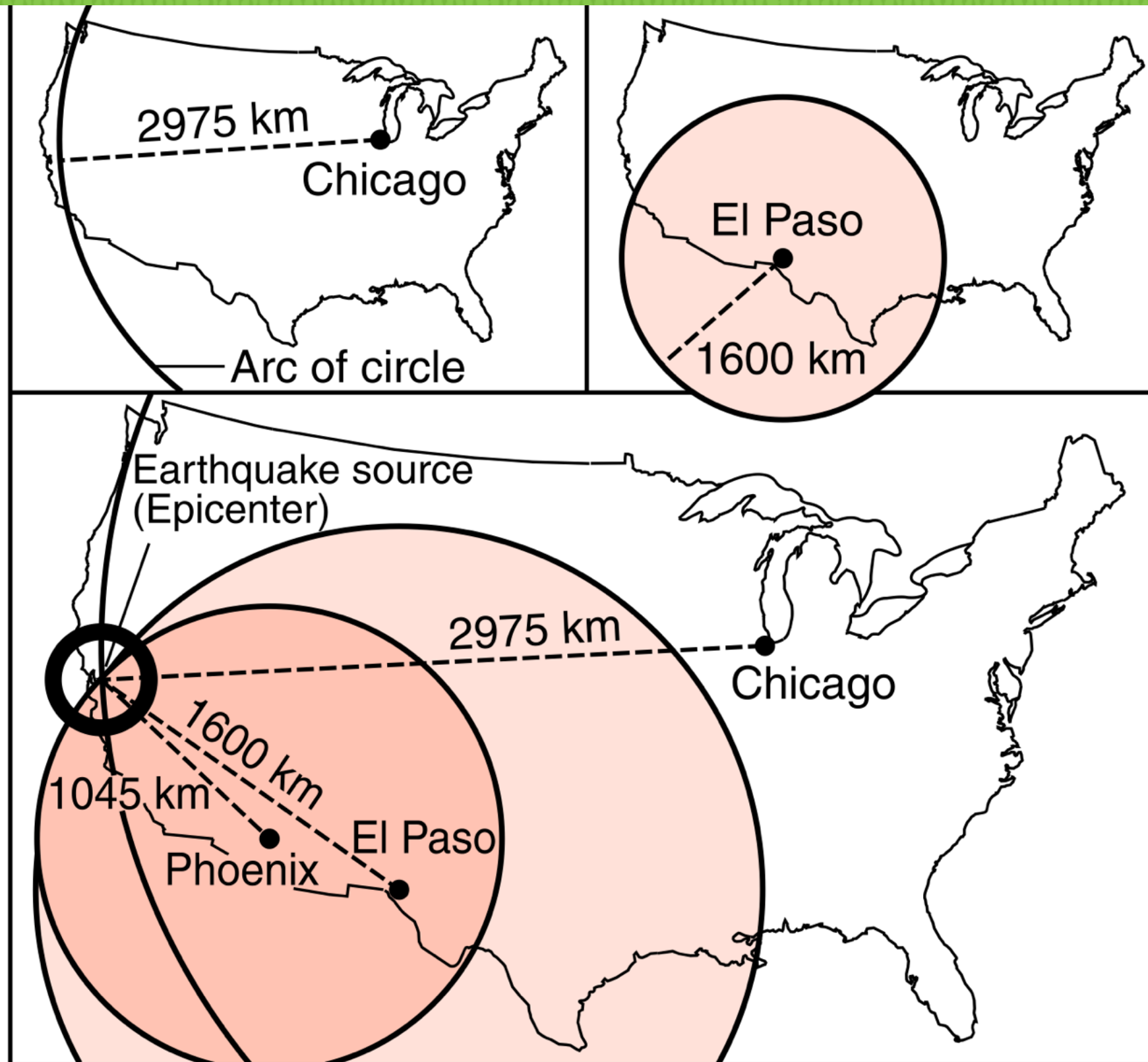
4. Use map scale to set compass to epicenter distance.

Goal: Students will be able to describe where an earthquake occurs.



5. Place point of compass at the station location and draw a circle around that location.

Goal: Students will be able to describe where an earthquake occurs.



6. When this is done for three stations, the intersection of all three circles is the location of the epicenter.



Earth's Interior
