# Plate Tectonics

**Slides from lectures preceding Plate Tectonics exercise**

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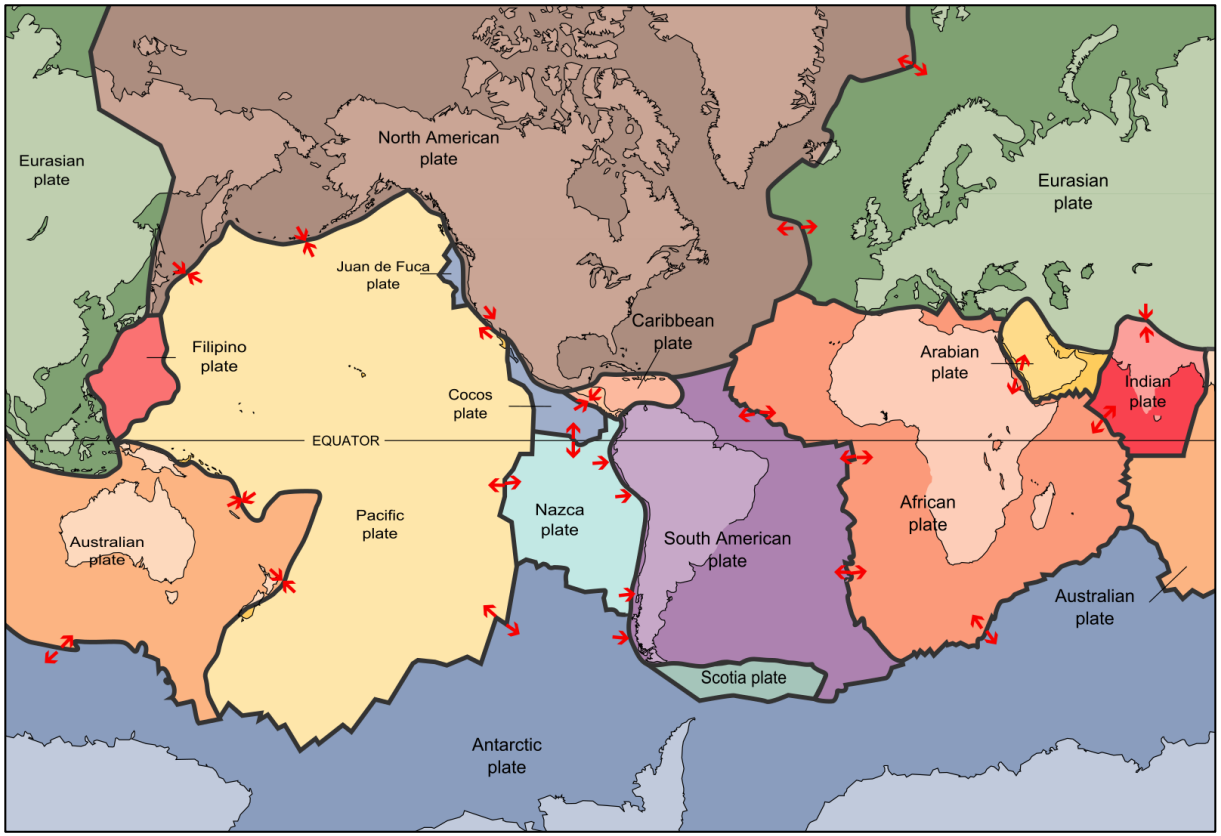
# Surface of a Plate

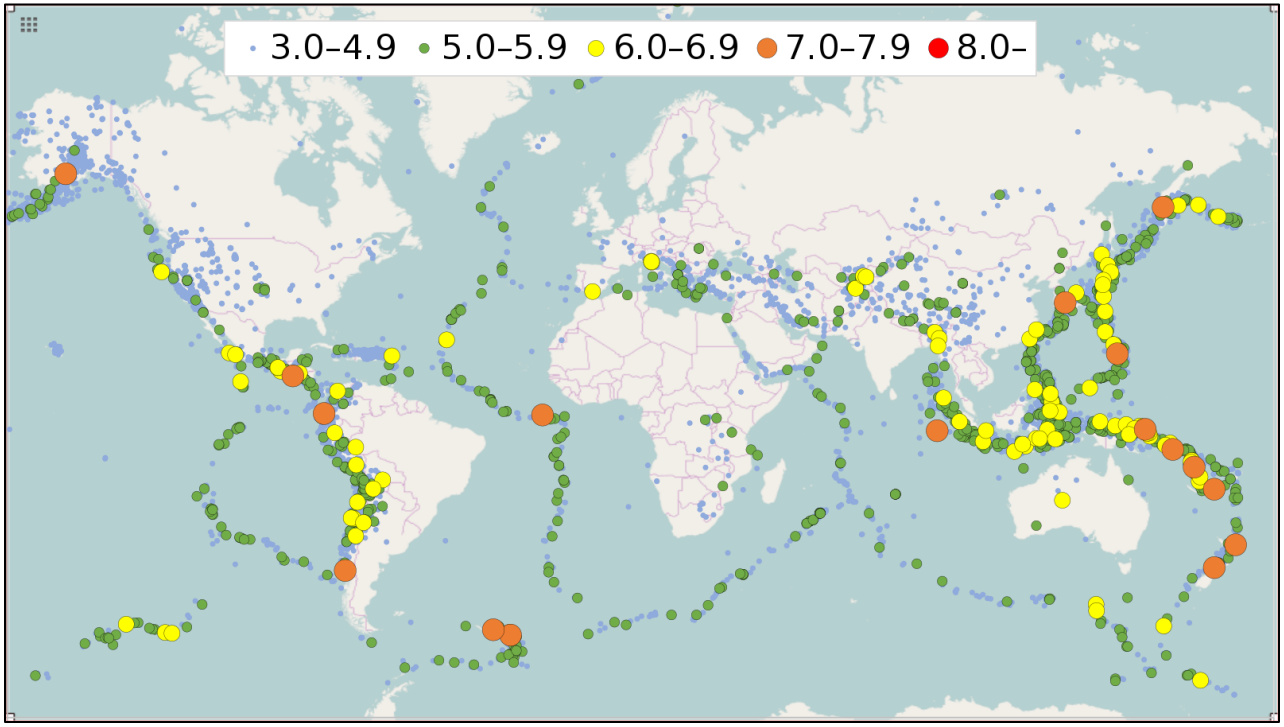
- **Composed of lithosphere = crust + uppermost mantle**
  - **Oceanic + continental lithosphere**
  - **Changes size with time**




https://commons.wikimedia.org/wiki/File:Plates_tect2_en.svg

# Tectonic Activity

- Occurs mainly at plate boundaries:
  - Volcanoes
  - Earthquakes
  - Mountain-building
- Plates outlined by EQ epicenters



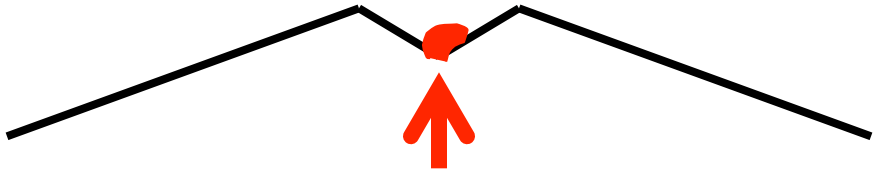

https://commons.wikimedia.org/wiki/File:Map_of_earthquakes_in_2016.svg

# Plate Boundaries

- **3 types, defined by *relative motions***
- **Stand on 1 plate, by boundary. How does the other plate move?**
  - **Moves away from you** ***Divergent boundary***
  - **Moves toward you** ***Convergent boundary***
  - **Slips past you** ***Transform boundary***

# 1. Divergent Boundaries

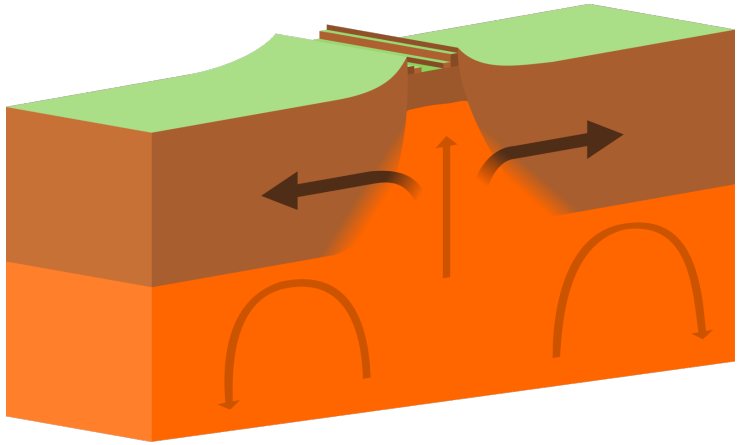
- **Plates move apart: a mid-ocean ridge forms (MOR)**
  - **Underwater volcanic mountains with a central rift valley**



- **Asthenosphere rises under ridge & partly melts**
  - **Lava cools → new lithosphere**
  - **Splits, then moves away from MOR**

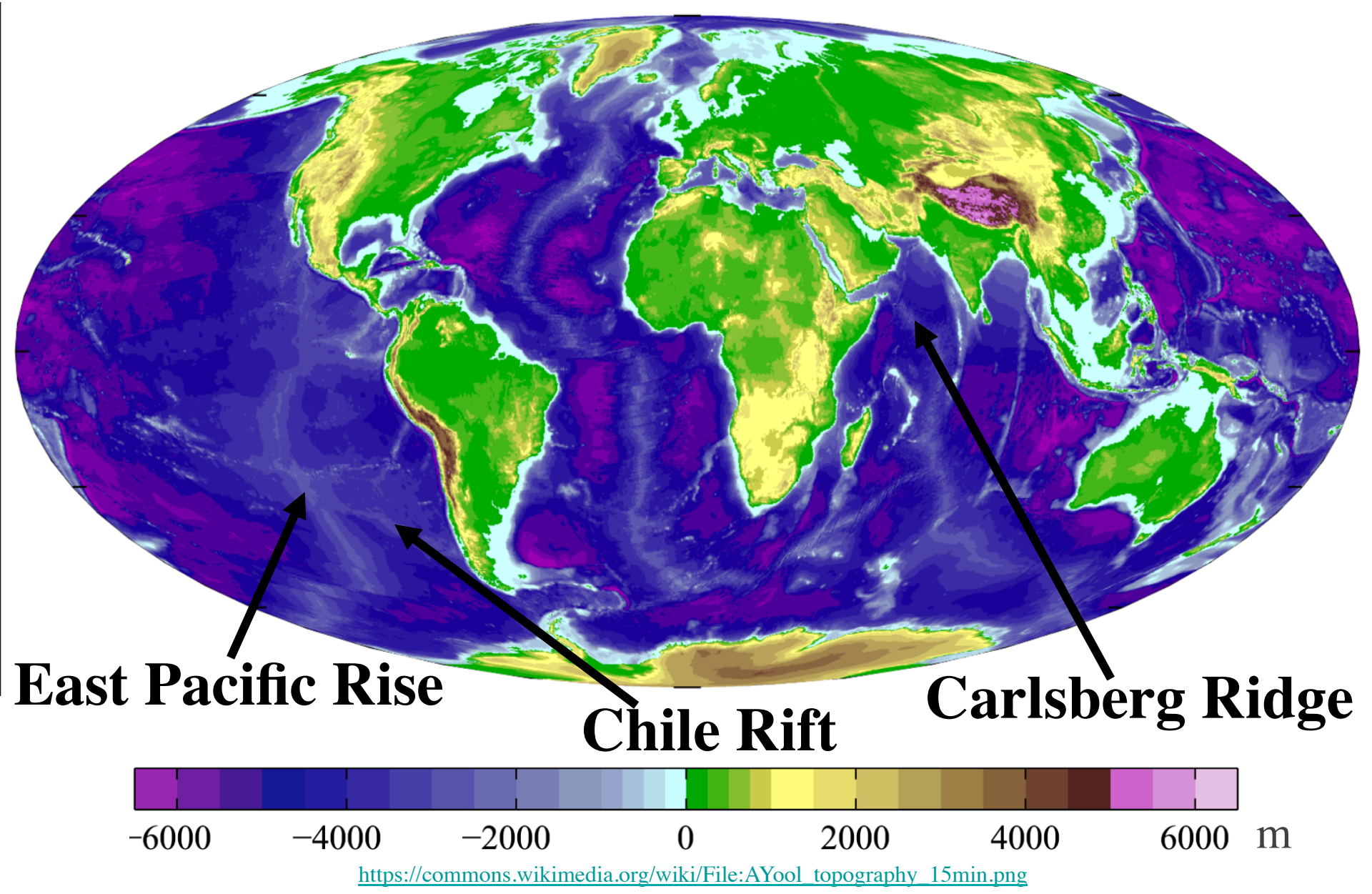
# What Happens at Divergent Boundaries?

- Tectonic activity
  - Non-explosive lava flows
  - Small earthquakes
- Ocean basins grow wider
- Continents move apart



https://commons.wikimedia.org/wiki/File:Continental-continental_constructive_plate_boundary.svg

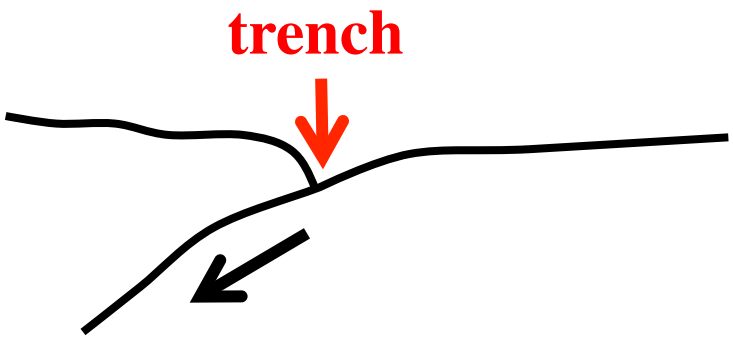
# Examples




https://commons.wikimedia.org/wiki/File:AYool_topography_15min.png

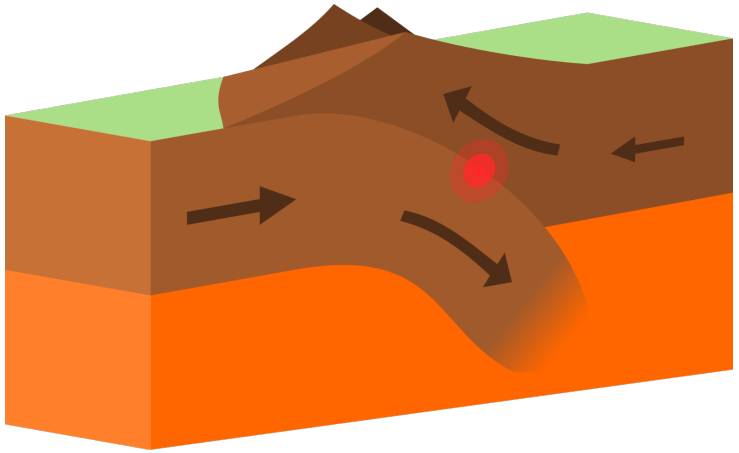
# 2. Convergent Boundaries

- **Plates move toward each other**
- **Marked by a deep narrow trench**
- **Also called *subduction zones***
  - **Old oceanic lithosphere bends…**
  - **Sinks into mantle…**
  - **Is destroyed**



# What Happens at Convergent Boundaries?

- Tectonic activity
  - Explosive volcanic eruptions
  - Major EQs
- Oceans get smaller
- Continents move closer together



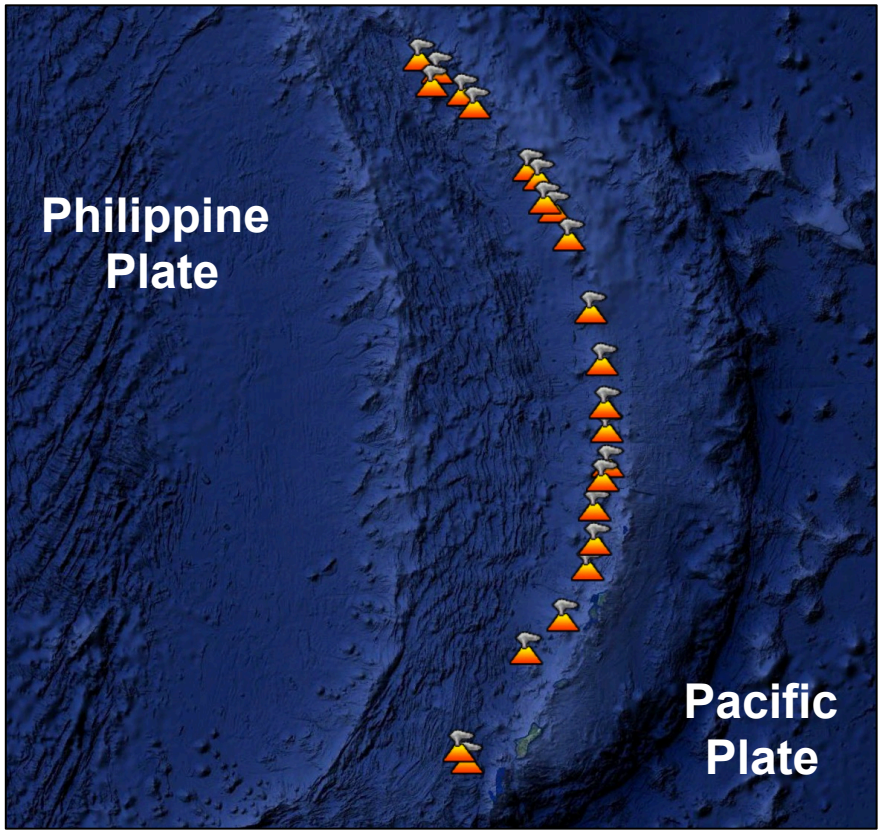
https://commons.wikimedia.org/wiki/File:Continental-continental_destructive_plate_boundary.svg

# Details of Convergent Boundaries

- **Three types:**

  **a) Ocean-Ocean**

  - **2 oceanic plates**
  - **One subducts (the older, heavier one)**
  - **A *volcanic island arc* forms**



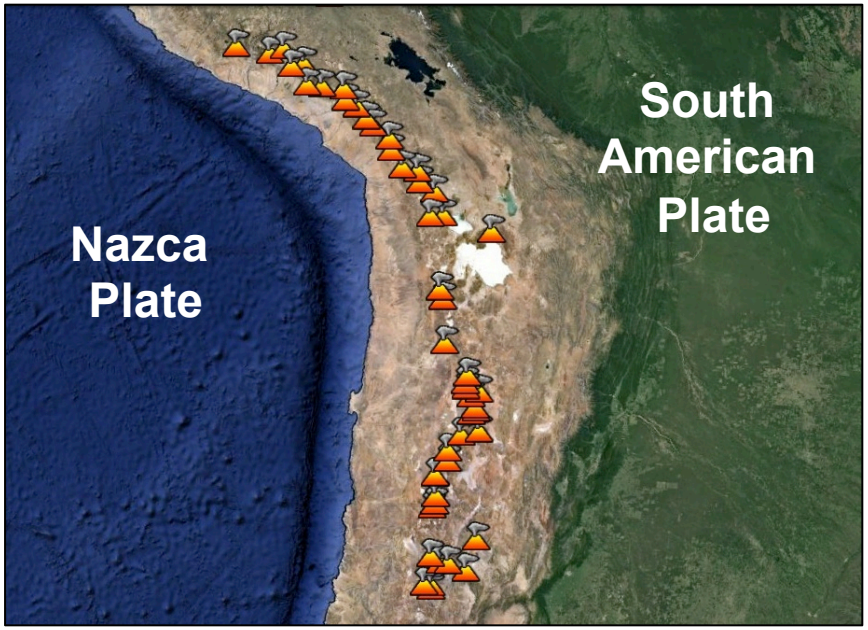

Screenshot from Google Earth of the Marianas Islands and Trench

# More Convergent Boundaries

- **Three types:**

  **b) Ocean-Continent**

  - **1 oceanic plate + 1 continental plate**
  - **Oceanic plate subducts**
  - ***Continental volcanic arc* forms**



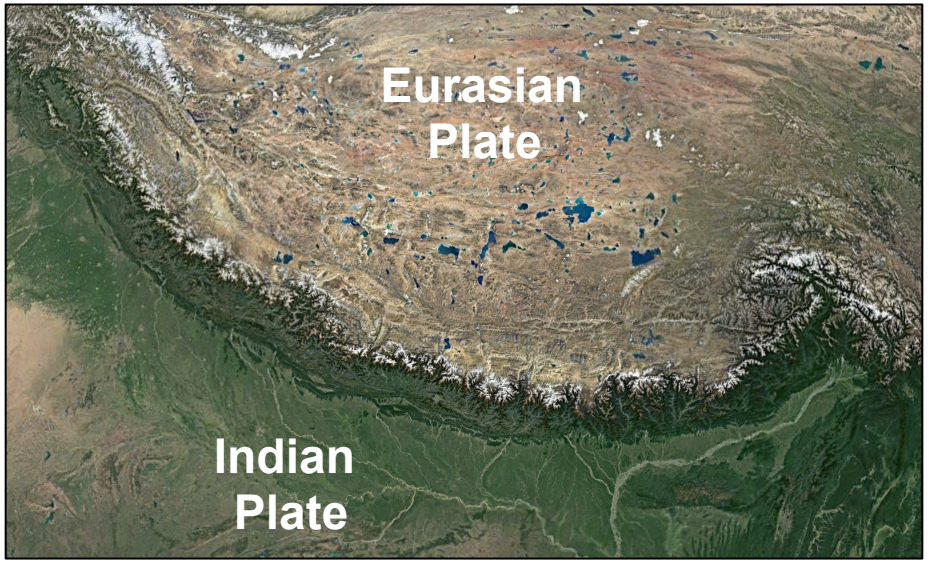

Screenshot from Google Earth of the southern Andes

# Other Convergent Boundaries

- **Three types:**

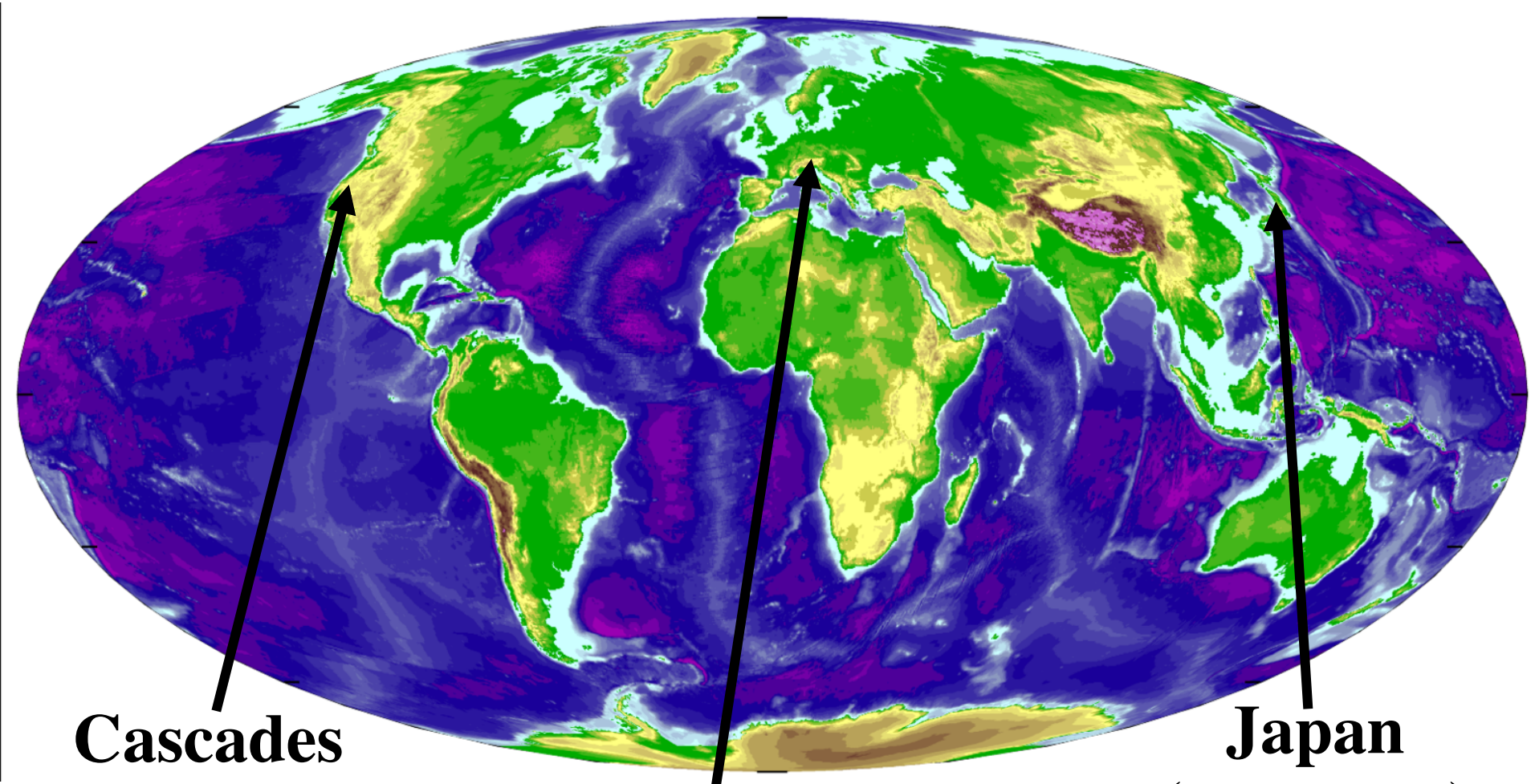
  **c) Continent-Continent**

  - **2 continental plates**
  - **Neither subducts – they collide**
  - ***Mountain range* forms**




Screenshot from Google Earth of the Himalayas

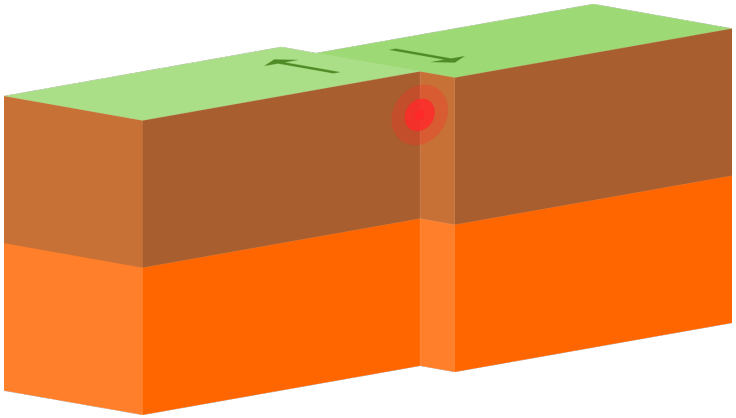
# Examples




https://commons.wikimedia.org/wiki/File:AYool_topography_15min.png

# 3. Transform Boundaries

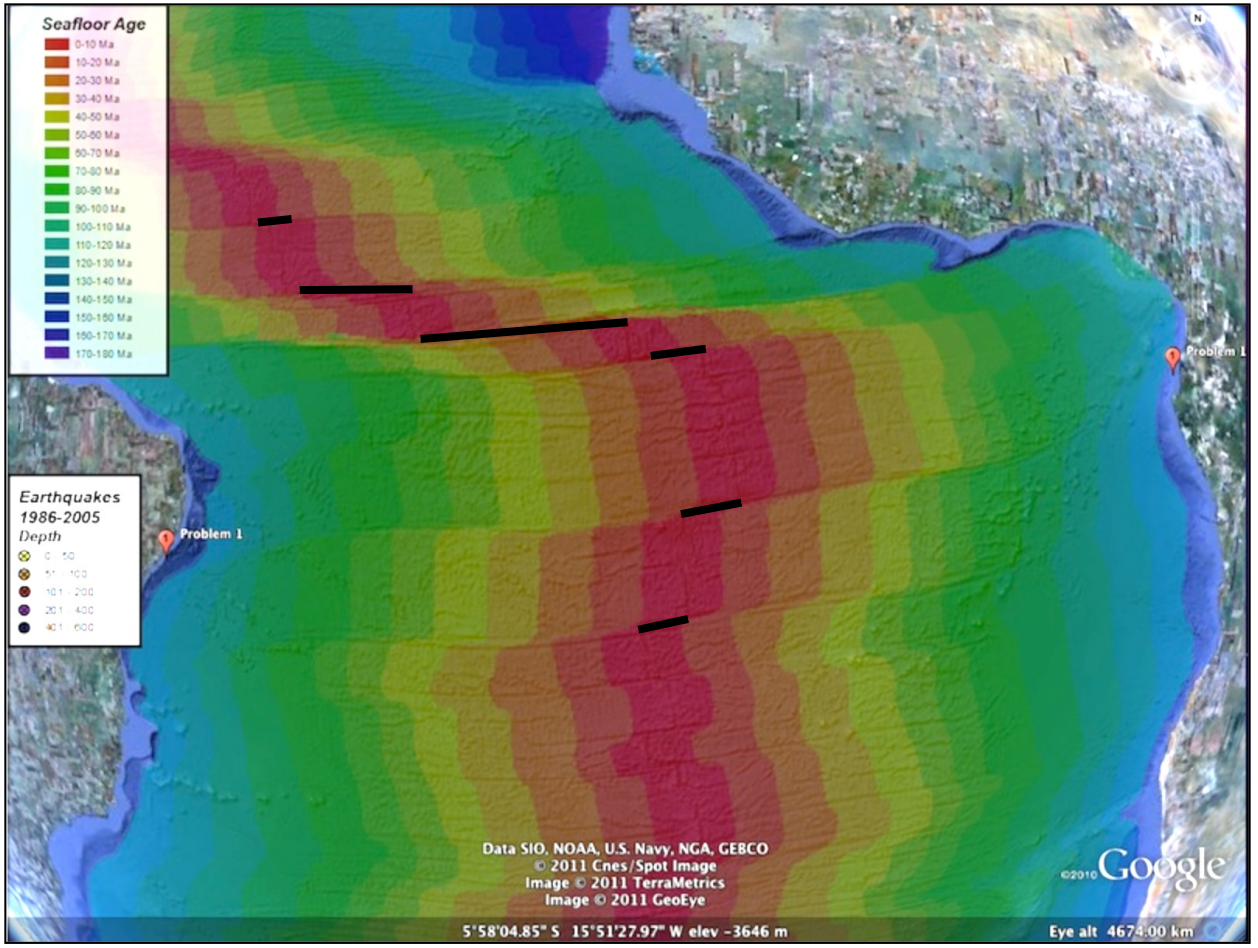
- **2 plates slide past one another**
- **Marked by a *transform fault***
  - **No volcanoes**
  - **No new crust forms**
  - **No old crust destroyed**
  - **Major EQs occur**



https://commons.wikimedia.org/wiki/File:Continental-continental_conservative_plate_boundary_opposite_directions.svg

# Where Are Transform Boundaries?

- Most are under oceans
- They connect segments of mid-ocean ridges (e.g., "stair-steps" in Atlantic Ocean)

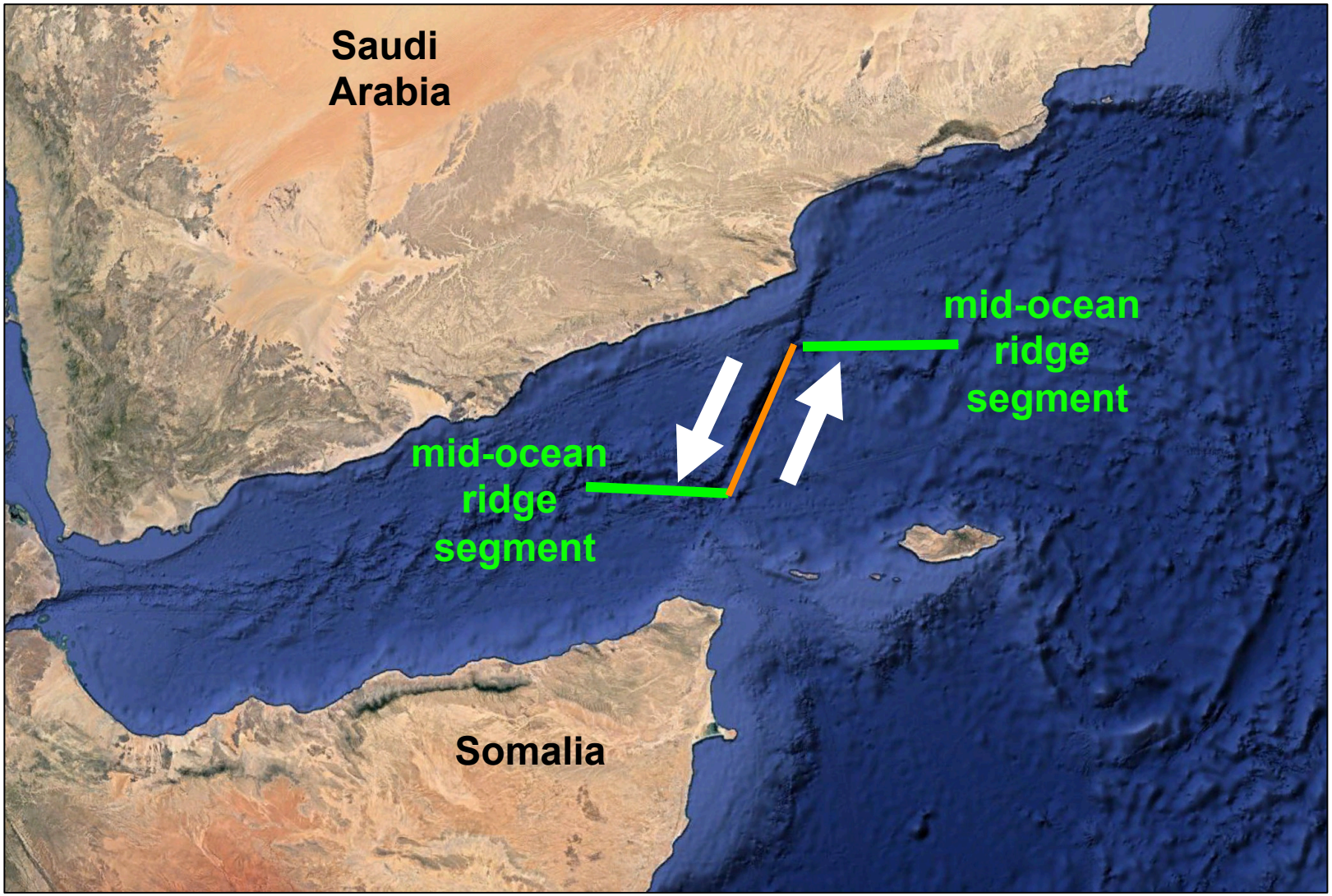



Screenshot from Google Earth of southern Atlantic Ocean

# Fault: Traditional Interpretation

- **Ridge was once continuous, then broken by fault**

This interpretation is wrong!!!

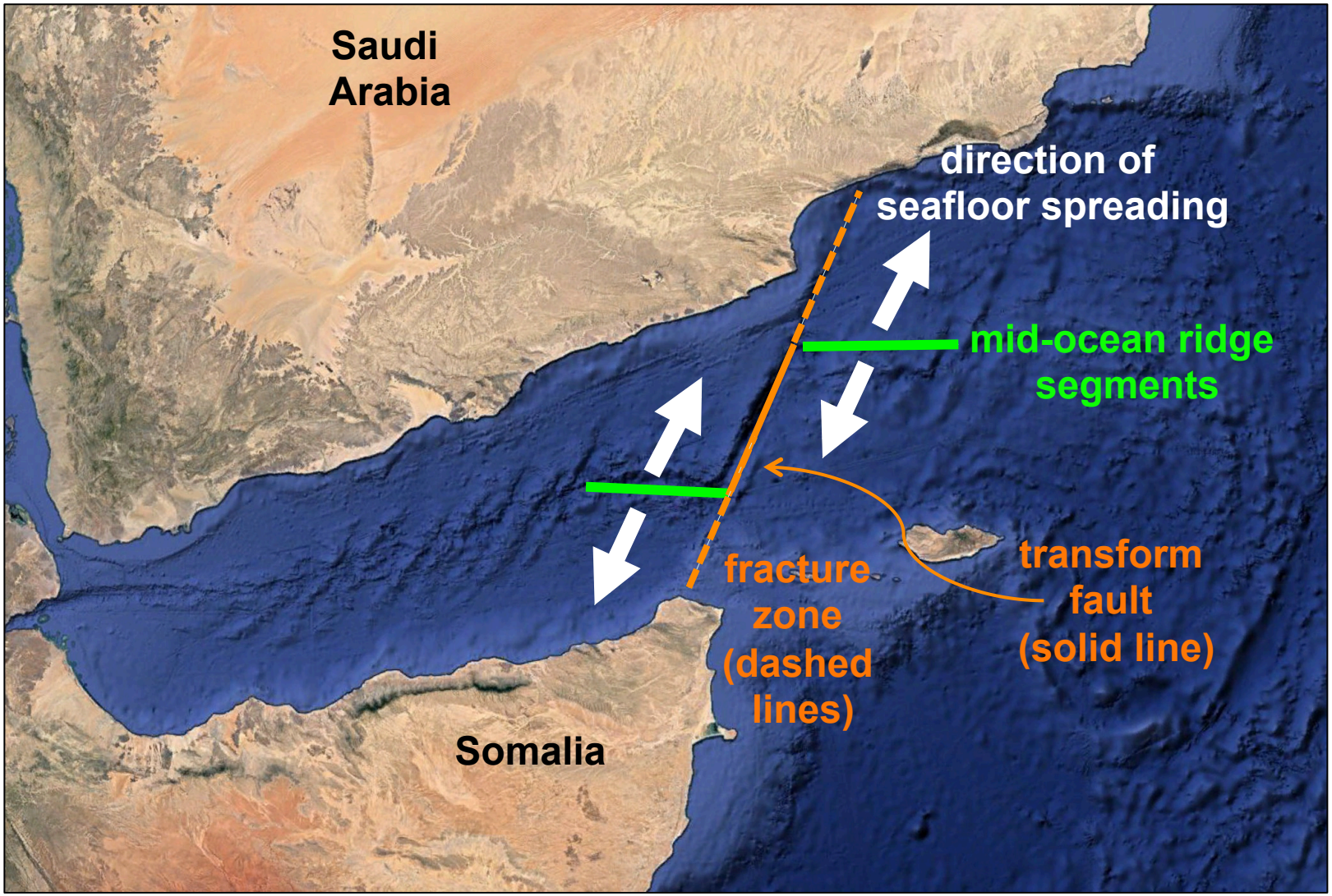



This interpretation is wrong!!!

Screenshot from Google Earth of the Gulf of Aden

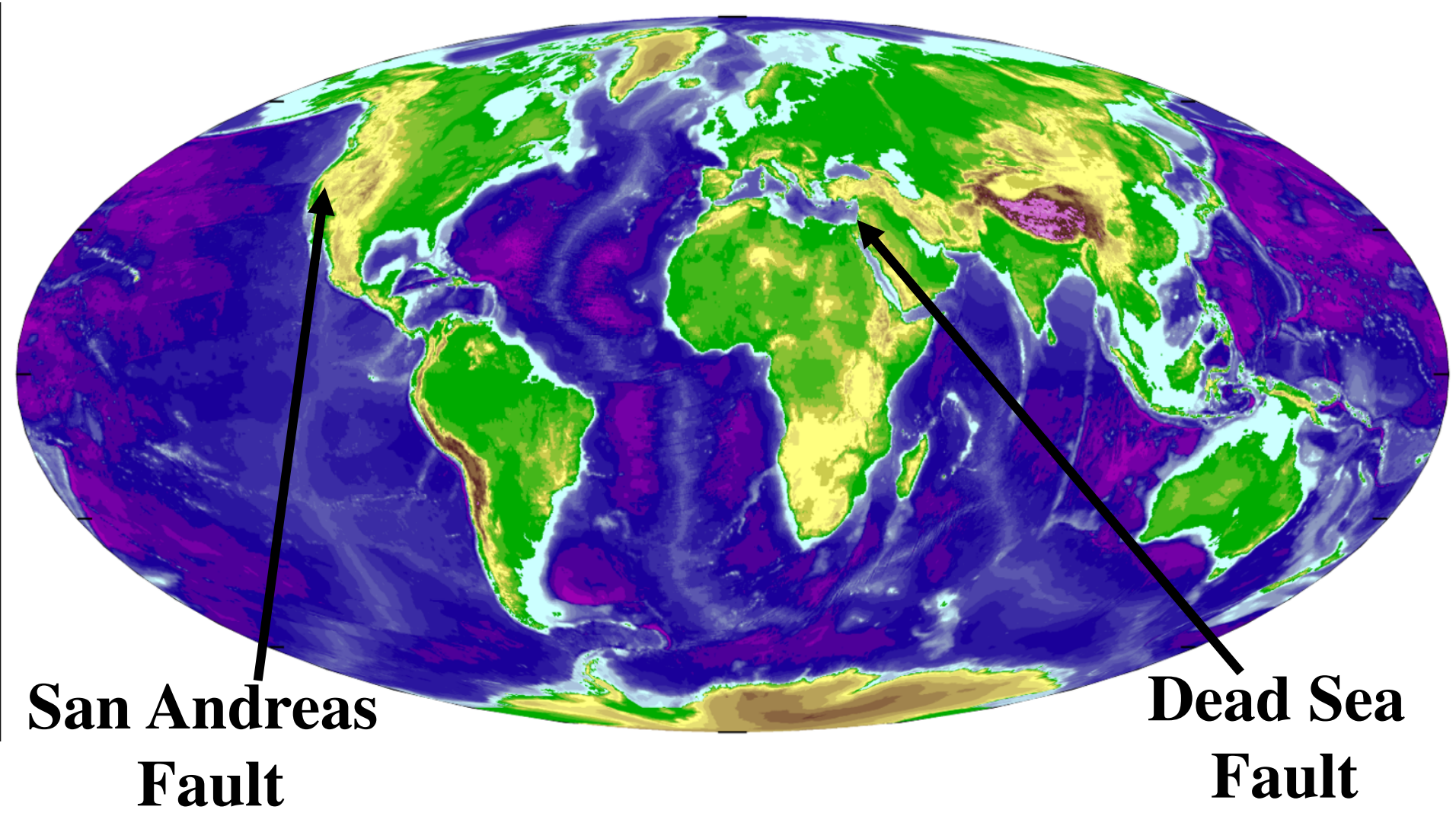
# Fault: Transform Interpretation

- EQs occur only along solid orange line




Screenshot from Google Earth of the Gulf of Aden

# Examples

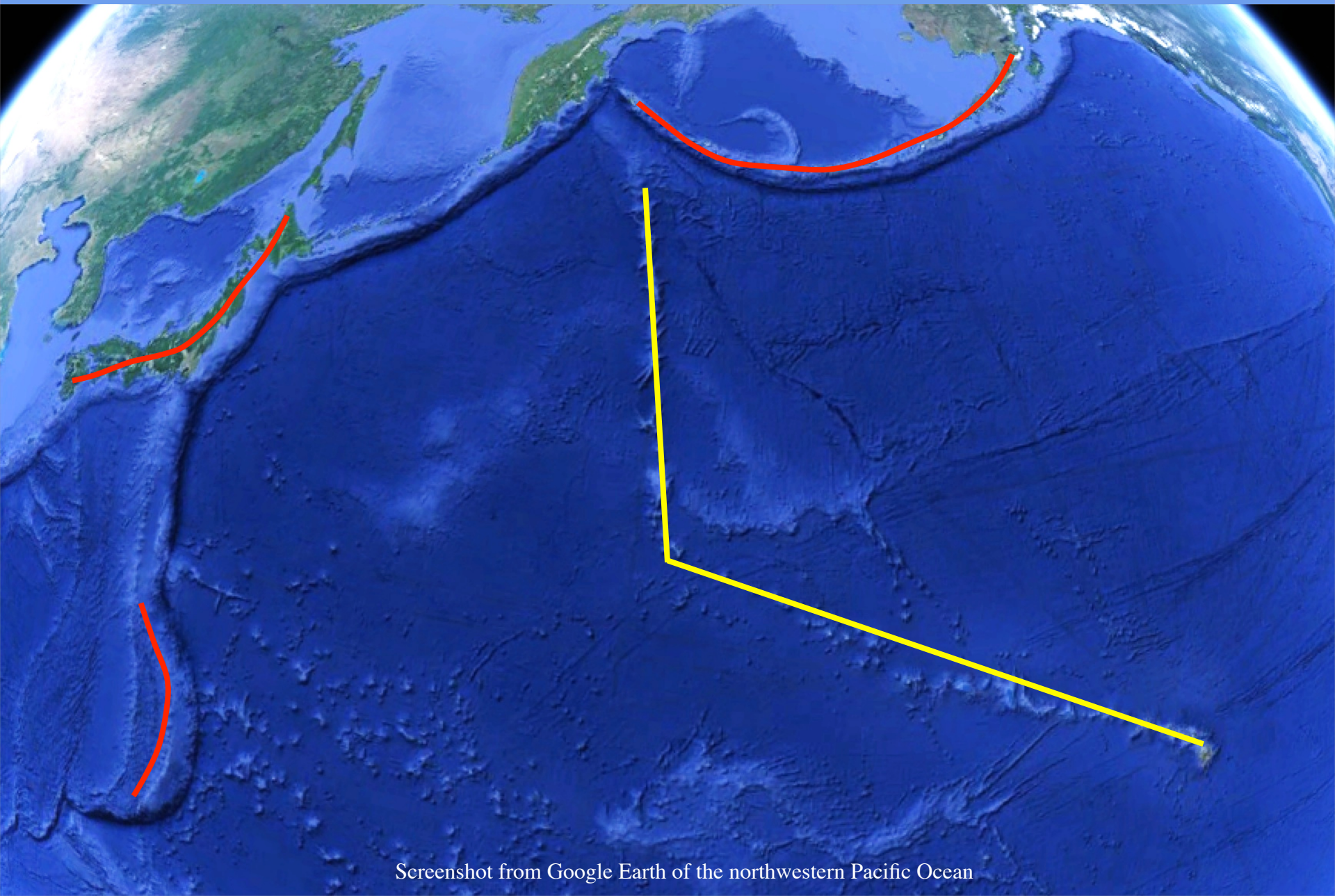



https://commons.wikimedia.org/wiki/File:AYool_topography_15min.png

# Another Aspect of PT

- **Early geologists noticed 2 types of volcanic mountains in the oceans:**
  - **Volcanic arcs around ocean margins**
    - o **Curved**
    - o **All are active**
    - o **All are ~ the same age**
  - **Volcanic chains in middle of ocean**
    - o **Straight**
    - o **Active at 1 end only**
    - o **Age changes along chain**

# Volcanic Mountains of the Pacific



Screenshot from Google Earth of the northwestern Pacific Ocean

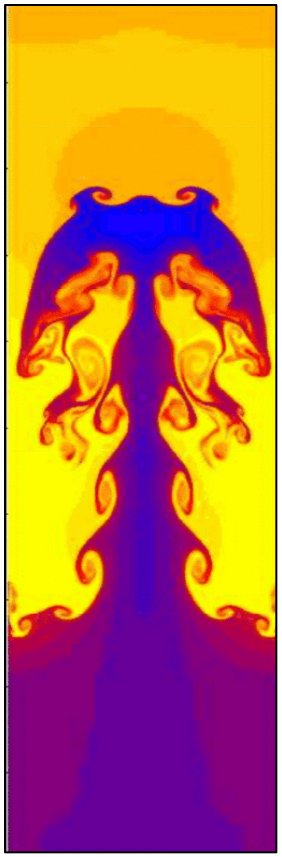
# What Is a Hotspot?

- **Def: Active volcano not in an arc**
  - **At 1 end of volcanic chain**
  - **Hawaii is a classic example**
- **Plate moves over hotspot (HS)**
  - **Old volcano stops, new one forms**
  - **Produces a chain of volcanoes**
    - **Age increases with distance from HS**

# What Makes a Hotspot?

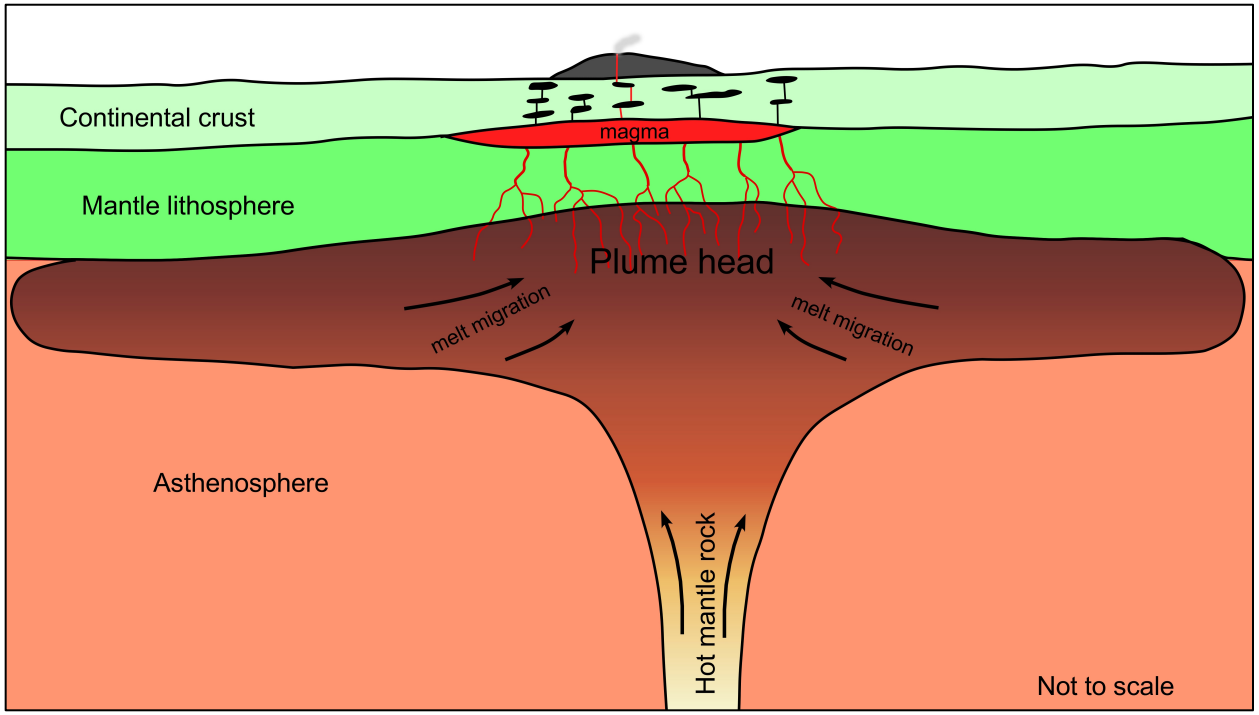
- ***Mantle plume*: column of hot rock that rises from the mantle**
  - **Partly melts**
  - **Fuels volcano at surface (= HS)**
  - **Plume + moving plate = *hotspot track***

**Mathematical simulation of a plume**

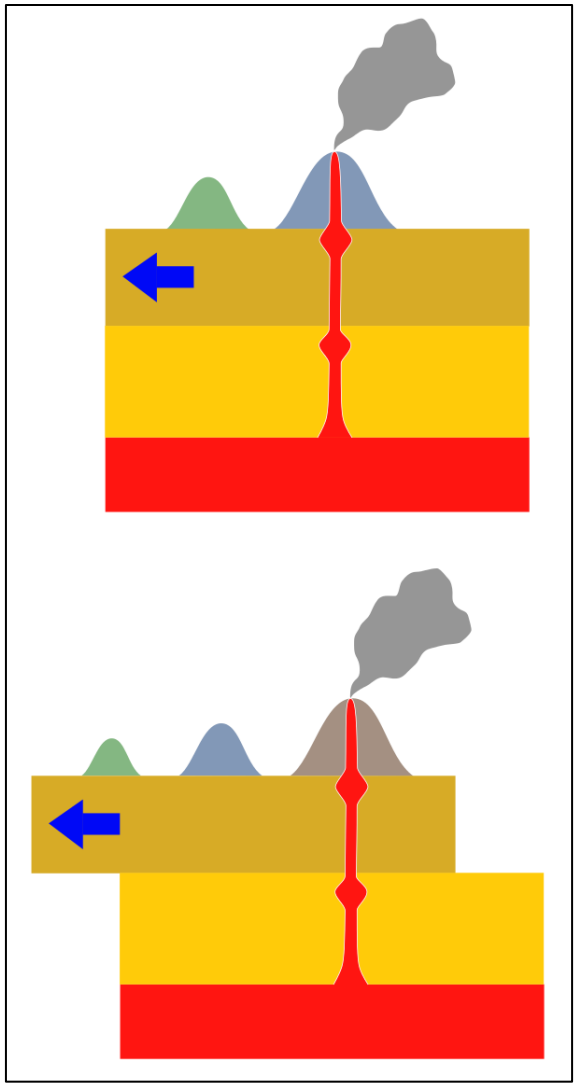


https://commons.wikimedia.org/wiki/File:HD-Rayleigh-Taylor.gif

# Hot Spots Illustrated




After Mark Richards et al, UC Berkeley
https://www.eurekalert.org/multimedia/pub/91103.php

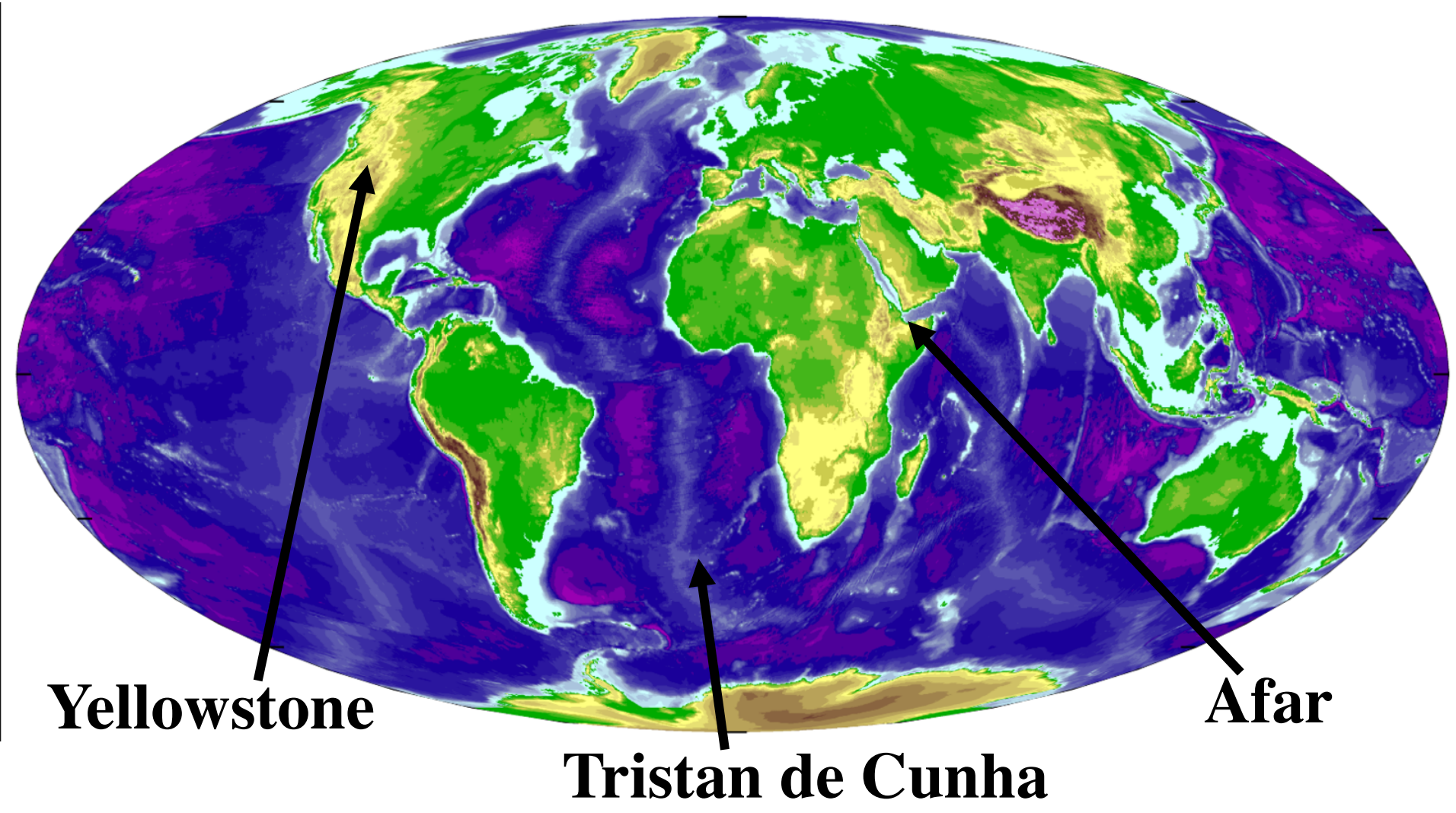


## Hot spot animation:

http://www.wwnorton.com/college/geo/animations/hot_spot_volcanoes.htm

https://commons.wikimedia.org/wiki/File:Hotspot(geology)-1.svg

# Examples

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**Teaching Notes and Tips**

This exercise is divided into three complementary sections. The exercise may be completed in one extended laboratory period, or individual sections may be assigned as separate, shorter activities or as homework.

Note that the Excel workbook file includes three worksheets that contain the key. The workbook given to students should have the following worksheets only: Data, Graph, Fig. 2.3, and Hawaii.

The maps in Part I are sufficiently detailed that students may zoom in and should be able to read all of the text.

Part II includes a scaled cross section of the South America subduction zone. There is a small version in the Student Instructions and a larger version in the Excel spreadsheet. The instructor may choose to discuss this diagram before students begin to work.

Students may need a review of algebra related to lines, slopes, and y-intercepts to interpret the graph in Part III.

Because computer software changes so rapidly, the instructions for accomplishing certain tasks with Excel might differ from those given in the student instructions. Thus, the instructor should be aware of possible difficulties using Excel.