

I. Objectives

1. Using Google Earth (GE) determine how fast the Earth's tectonic plates move relative to one another.

II. Introduction

Earth's tectonic plates are outlined by zones of active seismicity, volcanism and faulting. Some plate boundaries have oceanic subduction trenches associated with them. These are known as "convergent plate boundaries." These are zones where oceanic crust is subducted and consumed below continental crust. Oceanic crust is created along "divergent plate boundaries," areas such as the Atlantic's mid-ocean ridge, where fresh magma pushes up an amazingly continuous sub-sea mountain chain and cools to form new basaltic oceanic crust.

III. Materials

Bathymetry map provided by the instructor or from the class website, calculator, crayons or colored pencils, earths_tectonic_plates.kmz file downloaded from class website, age_of_ocean_floor.kmz file downloaded from class website

IV. Prelab Definitions

1. bathymetric
2. plate tectonics
3. subduction zone
4. convergent boundary
5. divergent boundary
6. oceanic crust
7. continental crust
8. Mid-Atlantic Rise
9. latitude
10. elevation
11. longitude

V. Lab Procedure

Part A: Divergent and Convergent Boundaries

You will be provided with a shaded bathymetric map of the world's oceans which was commissioned by National Geographic in 1980 (Tharp). The mid-ocean ridge system forms a set of sub-sea ridges that stretches over 64,000 km. It appears as a generally symmetric region of parallel ridges, alternating light and dark bands, and perpendicular transform faults that is most clear in the Atlantic Ocean. The divergent boundary is at the center of this zone.

1. On the shaded bathymetric map of the world's oceans, use a marker or crayon to trace the central ridge of the world's mid-ocean ridge system wherever you see it.

Another type of plate boundary, a subduction zone or convergent boundary, can also sometimes be seen in these figures. Subduction zones are sometimes called oceanic trenches because they are relatively deep features. They will appear as long dark features on these maps, although depending upon the perspective view, some continental shelves, also appear this way, for example off the east coast of the U.S. Often, a long chain of mountains can be found adjacent to active subduction zones.

2. Use a different color marker or crayon to trace the major mountain chains of the world. Then use a different color to trace the subduction zone trenches.

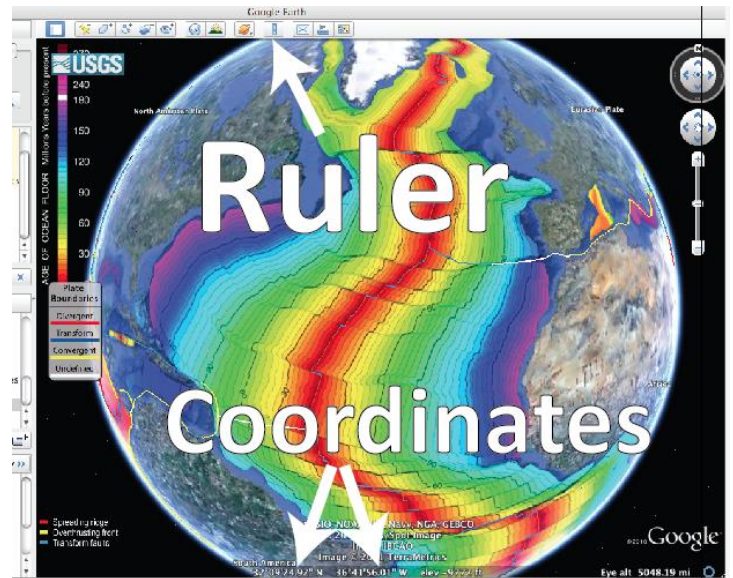
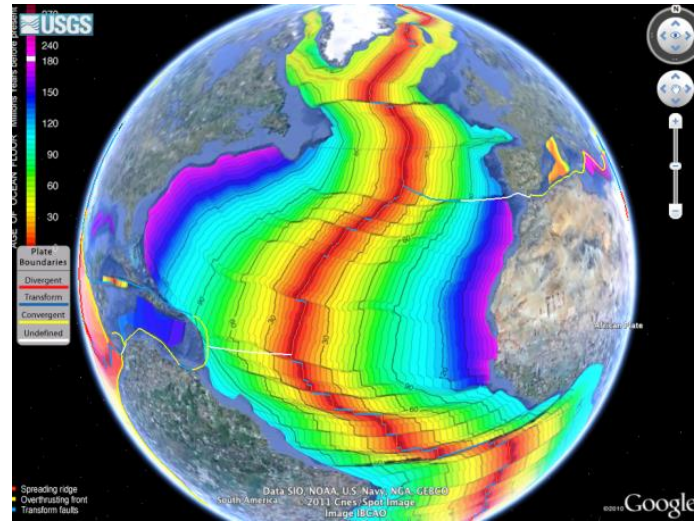
Part B: Google Earth

3. From the class website download the file earths_tectonic_plates.kmz and open it in GE.
4. On the left hand side of GE there is a "Places" box that should include earths_tectonic_plates once you open it. If earths_tectonic_plates is not already visible turn it on by clicking the check-box next to it. The colored lines represent tectonic plate boundaries. You can turn on/off various layers. In the lower-left panel you may want to turn off other layers so the only thing visible is the earths_tectonic_plates layer.
5. You can navigate around the earth using the navigation tools in the upper right corner, and the "grabber" hand. Navigate around the world looking at the various plate boundaries, especially the divergent boundaries.
6. Find Tucson by entering "Tucson, AZ" in the "Fly To" box in the upper-left corner of GE. Then zoom out a bit. Answer the questions for Part B in the Discussion Questions section of the lab.

Part C: Divergent Plate Boundaries, Sea Floor Spreading, and Plate Velocity

In this section you will use the age of the sea floor to determine how fast the tectonic plates are moving.

7. From the class website download `age_of_ocean_floor.kmz` and open it in GE. This layer shows the age of the rocks that make up the oceanic plates. Make sure the layers are turned on. The color legend in the upper left corner provides the age in millions of years. The image to the right shows a view of the Atlantic Ocean.
8. Navigate around the world and observe patterns in the distribution of rock ages.
9. Navigate to the Atlantic Ocean and answer the questions for Part C in the Discussion Questions section of the lab.
10. We can use the pattern of seafloor age to determine how fast the plates are moving. To calculate velocity, we need to measure the perpendicular distance from the spreading ridge to a point on the plate. GE has a “ruler” tool which is in the toolbar along the top of the screen. If it is not there, Go to “View,” and turn it on.
11. When you click the Ruler tool, a little box opens asking you what unit of length to use. Change it to kilometers.
12. Now you can measure the distance between two points by clicking on the two points. As a check, the distance from the southern tip of Baja California to the southern tip of Florida is about 2900 km.



13. Measure a few distances from the Mid-Atlantic ridge to points away from the ridge.

Notice while moving the mouse around in GE there are three numbers along the bottom of the screen that constantly change. These numbers are the coordinates of the location of the cursor or ruler tool on the actual Earth. We use latitude to measure the North or South location of a point, longitude to measure the East or West location of a point, and elevation for vertical position. Longitude is measured in degrees-minutes-seconds East or West (E,W) and latitude is measured in degrees-minutes-seconds North or South (N,S)

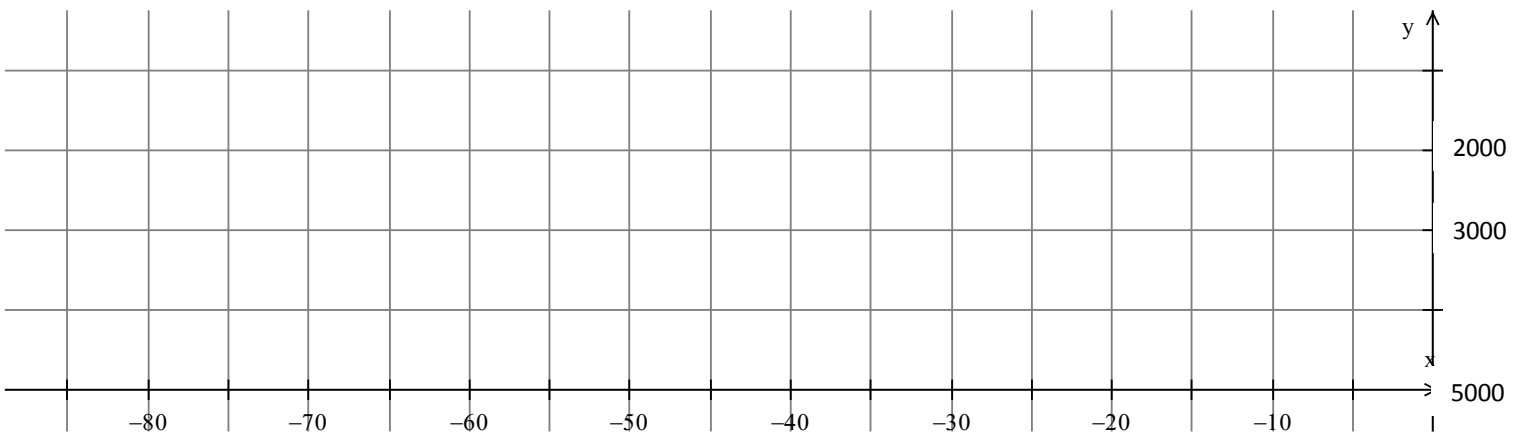
17. Based on your results, does it matter which direction you measure away from the ridge? Explain.

18. Do the plates appear to be moving symmetrically away from the ridges? Explain.

19. Is one plate moving away faster than the other? If yes, why, if not, why not?

20. Do the velocities you determined above make sense? Are they reasonable? Explain why your velocities are reasonable. If they are not, redo your calculations. Hint: The plates move at about the same rate that fingernails grow.

21. Create a bathymetric profile across the N. Atlantic Ridge and East Pacific Rise (use the same grid, below). Go to Tools, Options and change the elevation units to meters/kilometers. Rather than using distance for the x-coordinate, use time, with 5 m.y. intervals. Assume the profile is symmetric.



VI. Lab Discussion

Part A

1. Where is the oldest ocean floor?
2. Where is the youngest ocean basin?
3. Why is the Mediterranean Sea so old?
4. Describe the differences you see in the two bathymetric profiles you create in the last step.

Part B

5. What type of plate boundary is closest to Tucson? Are there other plate boundaries nearby?

Part C

6. Describe as completely as possible the pattern of ages in this region. (For ex: where are the youngest rocks, the oldest rocks, and is there a systematic way the ages change from place to place?)

Lab courtesy of Dr. Jim Washburne