



Lab 8A: Investigating Tectonic Plate Boundaries Using Online Geospatial Technology

NAME: _____ PERIOD: _____ SCORE: _____

Activity: Discover and investigate tectonic plate boundaries by analyzing maps showing seismic and volcanic activity

Learning Outcomes:

- (1) Discover the physical processes that occur along tectonic plate boundaries.
- (2) Use plate boundary features to classify tectonic plate boundary type.
- (3) Calculate ocean floor spreading rate using geochronological data from the ocean floor.
- (4) Experiment with online geospatial technology.

MAP URL: <http://arcgis.com>

A. EXPLORE AND ANALYZE. MAP #1: What can world volcanic activity tell us about tectonic plate boundaries?

1. Type in the URL listed above. Click on "Map" in the white bar at the top of the page.
2. Make changes to the base map of the United States that is displayed by clicking on "Modify Map" in the upper right hand corner of the page.
3. Select the "Basemap" button on the upper left hand corner of the page. Click on the map selection named "Terrain with labels."
4. Zoom in on the United States until the map scale on the lower left side of the map reads 0 to 40-60 miles. Investigate the terrain features called mountains by scrolling along the coast line of North America to South America. Starting near Juneau, Alaska write down the names of the major mountains along the coast line until you reach the southern tip of Chile in South America:
 - (a) Near Juneau, Alaska: _____
 - (b) Prince Rupert, British Columbia Canada: _____
 - (c) East of Seattle WA and Portland OR: _____
 - (d) Eureka to Los Angeles, CA: _____
 - (e) Mexico: _____
 - (f) Peru and Chile: _____

5. Zoom out to around 600 miles on the map scale and scroll around so you can see the North and South American continents. Describe the pattern you see in the location of mountain ranges on both of these continents: _____

6. Now you are going to add a layer to your map showing the locations of volcanoes in the world. Go to the toolbar at the top left of the page and click the "Add" button. Click on the "Search for Layers" tab in the drop down menu. In the search box type the word "volcanoes." In the "results found" box, find "World_Volcanoes" and click on the "add" button to the right. Your map will now be populated with the locations of volcanoes worldwide.

7. Zoom out to 600 miles on the map scale so you can see the entire Pacific Ocean and the North and South American continents, Asia and Australia. What pattern do you see in the locations of the volcanoes? _____

8. The volcanoes found around the Pacific Ocean form what is known as the Pacific Ring of Fire and these volcanoes show the location where tectonic plates meet at convergent plate boundaries.

9. Zoom back in to the North and South American continents. What do you notice about the locations of these volcanoes and the mountain ranges you listed in #4 above? _____

10. The volcanoes are represented by different colored triangles. These show different types of volcanoes. What is the predominant color of triangle found in these mountains? _____

11. Scroll up and down the coast of both continents and click on the yellow volcanoes. What type of volcano are these? _____.

12. Stratovolcanoes (sometimes called composite) are towering volcanoes you see in Hollywood movies. These are built from mainly intermediate composition magmas which result from the subduction (or sinking) of an oceanic tectonic plate beneath a less dense continental plate. These volcanoes are key features along convergent plate boundaries with subduction.

13. When two oceanic plates collide, one plate is subducted under the other and features called volcanic island arcs are formed at the subduction boundary. Go to the toolbar at the top of your map and click the "basemap" button and change your map to "Oceans." Zoom out/in to 300 miles on the map scale and search the Pacific Ocean rim to find at least two examples of volcanic island arcs. List them below:

(a) Volcanic Island Arc #1: _____

(b) Volcanic Island Arc #2: _____

14. Other features found along convergent plate boundaries with subduction include deep sea trenches. These are deep “canyons” found at the location where a subducting plate is sinking back into the upper mantle. Zoom out to see the entire Pacific Ocean and locate and name three deep sea trenches:

(a) Deep Sea Trench #1: _____

(b) Deep Sea Trench #2: _____

(c) Deep Sea Trench #3: _____

15. Scroll out to look at the distribution of volcanoes worldwide. How can you explain the glaring absence of volcanic data on the east coast of North and South America and the general lack of volcanic data on the largest continent, the Eurasian continent?

16. Go back to the “Results found” box on the left of your map and click “remove” on World_Volcanoes to remove the volcanic data on your map.

B. EXPLORE AND ANALYZE. Map#2. What can world seismic (earthquake) data tell us about tectonic plate boundaries?

1. Add a new layer by searching for “earthquake depth.” Select “Depth2Epicenter” in the “Results Found” box and click “add.”

2. Zoom out until the map scale reads 400 miles. What is the earthquake data showing you? What patterns do you see? Explain: _____

3. Note that the earthquake data is color coded. Click on the different colored dots in different locations and scan the information that comes up next to each dot. What do these color codes represent? _____

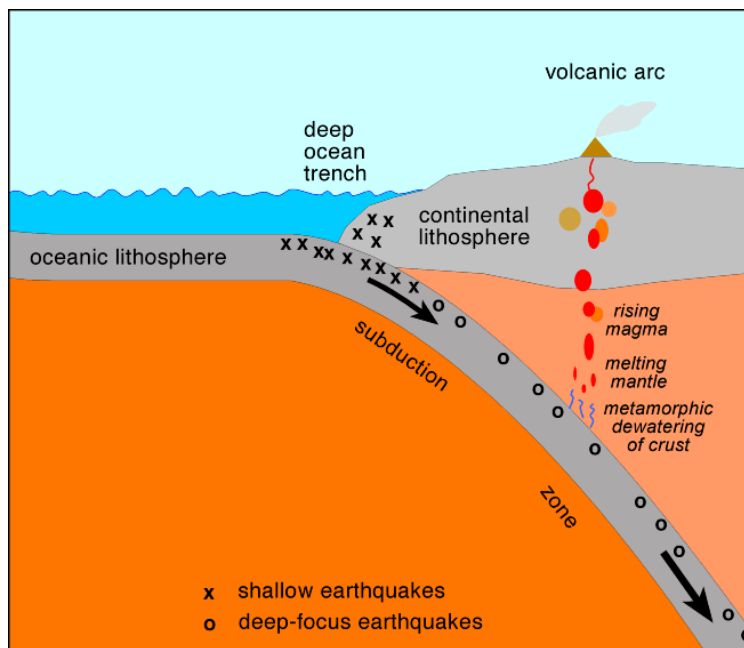
Click on the 3 different colored dots and determine the depth range in earthquake focus depths for each color:

(a) red: _____ (b) orange: _____ (c) yellow: _____

4. Zoom out and scan the earthquake data in the Pacific and Atlantic Oceans. Look at the data on the ocean floor and on the continents. What patterns do you see in the data (are earthquakes randomly located; are earthquake focus depths random, etc.)?

5. Zoom back to the Pacific Ocean and scan the earthquake data around the Pacific Rim. Specifically focus on the data (a) on the west coast of South America near the borders of Peru, Chile and Bolivia and (b) in the western and northern Pacific Ocean in the vicinity of the Tonga, Philippine, Mariana and Aleutian Trenches. After analyzing this data what is the relationship between earthquake focus depth and earthquake distance from a coast line or trench?

6. The relationship between earthquake depth and distance from the coastline or trench is characteristic of a convergent plate boundary with subduction. As the subducting plate sinks into the mantle, shallow focus earthquakes occur at the trench as the plate grinds past the overriding plate. As the subducting plate sinks deeper into the mantle, it begins to melt and the movement of magma at this depth triggers the deeper focus earthquakes as illustrated in the diagram below.



Earthquake focus depth at a subduction zone.

7. The location of the earthquake data can also provide information concerning the angle a tectonic plate is subducting. Steeper angles of subduction place the deeper focus earthquakes closer to the plate boundary (at the coastline or trench). With low angles of subduction, the deeper focus earthquakes occur at greater distances from the coastline or trench.

8. Zoom out and compare the earthquake data found at the plate boundary near the Tonga Trench in the west Pacific to the earthquake data found at the Peru-Chile trench off the coast of South America. Find the deep focus earthquakes (500-600 mile depths)

at both locations and use the measuring tool at the top of the map under the "measure" button to measure their distances from their respective plate boundary near each trench. Which boundary has the greater angle of subduction? _____

9. Zoom out and center the map in the North Atlantic Ocean and look at the earthquakes that are located in the middle of the ocean. Click on several of the earthquake data points that form a line of earthquakes on the ocean floor. What is the average depth of these earthquakes? _____

10. These shallower earthquakes mark the location of tectonic plate boundaries that are pulling apart from each other, known as divergent boundaries. At this location magma from the mantle is surfacing on the bottom of the ocean creating new seafloor. This results in the formation of long underwater mountain chains called mid-ocean ridges. These features are characteristic of divergent plate boundaries. Scroll around at look at the ocean floor earthquake data on the map and locate the five major mid-ocean ridges (MOR) and name them below:

(a) MOR #1: _____

(b) MOR #2: _____

(c) MOR #3: _____

(d) MOR #4: _____

(e) MOR #5: _____

11. Go back to the search box on the left side of your map to turn off the earthquake data by clicking "remove" for the "Depth2Epicenter" search result.

C. EXPLORE AND ANALYZE. Map #3: Geochronology and how fast do tectonic plates move?

1. Create a new layer by typing in "ocean floor age" in the "Find" box. This results in one find in the search box. Add this layer to the map. Scroll over and center the map on the North Atlantic Ocean with the east coast of the United States showing using a map scale up to 300 miles. What do the color stripes represent? _____

2. Determine the age of the ocean floor coded in different colors. Click the blue "Done Adding Layers" button on the bottom left side "Search for Layers" legend. Hover over the captions next to the checked boxes for each entry and click on the first icon that says "Show legend".

(a) Bright red age range is: _____

(b) The lime green age range is: _____

3. What pattern do you notice in the color coded data? _____

4. What ocean floor feature is found at the center of the bright red stripe? _____

5. As you have discovered, the color pattern on this map represents the age of the ocean floor. The bright red stripe is centered over the Mid-Atlantic Ridge where new sea floor is being formed. Look at the pattern again and describe the relationship between the age of the seafloor and its distance from a MOR: _____

6. The bright red stripe centered on the Mid-Atlantic Ridge represents ocean floor basalt that ranges in age from the present back to 9.7 million years ago. The oldest seafloor is shown in lime green, the oldest of which dates back to 180 million years ago. By knowing the age of the basalt rocks on the ocean floor and the distance the rock is found from the mid-ocean ridge you can get an estimate of how fast the ocean floor is spreading away from the mid-ocean ridge.

7. Compute the speed at which the tectonic plate is moving away from the Mid-Atlantic Ridge. Use the rate equation in the box below:

$$Velocity = \frac{Distance}{Time}$$

(a) Center your map so you see the coast of South Carolina, Georgia and Florida and the Mid-Atlantic Ridge with the map scale reading 300 miles. Use the measuring tool under the "measure" button and measure the distance from the Mid-Atlantic Ridge to the farthest tip on the edge of the lime green stripe across the Hatteras Plain. For this measurement use kilometers (click on "miles" in the measurement tool bar and select "kilometers" in the drop down menu). Distance is: _____ km.

(b) Convert the distance into centimeters by multiplying by 100,000 (1 km = 100,000 cm).

(c) Use the age of the ocean floor at the end of the lime green stripe for "Time".

(d) The average velocity this tectonic plate traveled over the past 180 million years is: _____ cm/year.

(e) Convert your answer to mm/year by multiplying by 10: _____

(f) Compare this answer to the actual plate velocity by returning to your map and searching for a small red arrow pointing to the west near the word "Atlantic" in Mid-Atlantic Ridge. Click on this arrow to find the velocity displayed in the dialog box.

Actual velocity is: _____ mm/year.

8. Go back to the search box on the left side of your map to turn off the ocean floor age layer by clicking "remove" for the search result.

D. SYNTHESIZE AND EVALUATE: Explain how the data you have explored and analyzed on the maps you've prepared help you determine the type of plate boundary.

1. Use the data table on the next page to summarize the results of your analysis. List the geologic features and processes common to each boundary

Boundary Types:	Map #1: World Volcanoes	Map #2: World Seismic Activity	Map #3: Geochronology
Convergent Boundary with subduction			
Divergent Boundary			

E. APPLICATION: Identify plate boundaries on a world plate tectonics map.

1. Using the color codes below, high the different type of plate boundary on Map #4 (on the last page) based on your analysis of geologic features and processes common to each boundary type. NOTE: FOR THE PURPOSE OF THIS EXERCISE, TRANSFORM BOUNDARIES ARE NOT HIGHLIGHTED OR DISCUSSED.

- Color Codes: Convergent boundaries with subduction: Green
Divergent boundaries: Yellow

2. To assist, go back to your map, click "Basemap" and select "Terrain with Labels". Then modify the map by searching for "Earth's Tectonic Plates". Add the layer "Earth's Tectonic Plates". Then add "World Volcanoes" and "Earthquake Depth" data back to the map. Use this map as reference as you complete Map #4.