**LAB MODULE 13: PLATE TECTONICS**

**Note:** Please refer to the GETTING STARTEDmodule to learn how to maneuver through, and how to answer the lab questions, in the Google Earth (GE.gif) component.

**KEY TERMS**

You should know and understand the following terms:

|  |  |  |
| --- | --- | --- |
| Continental Drift | Pacific Ring of Fire | Reverse Fault |
| Earthquakes | Pangaea | Subduction |
| Hotspots | Plate Convergence | Transform Fault |
| Normal Fault | Plate Divergence |  |
| Overthrust fault | Plate tectonics |  |

**LAB MODULE LEARNING OBJECTIVES**

After successfully completing this module, you should be able to do the following tasks:

* Explain the theory of plate tectonics
* Explain the theory of continental drift
* Identify and describe types of plate movement
* Identify and describe the three types of volcanoes
* Explain the concept of hotspots
* Compute the rates of plate movement
* Identify and describe the different types of faults

**INTRODUCTION**

This module examines plate tectonics. Topics include continental drift, tectonic landforms, plate boundaries, faults and hotspots. While these topics may appear to be disparate, you will learn how they are inherently related. The module start with four opening topics, or vignettes, which are found in the accompanying Google Earth file. These vignettes introduce basic concepts of the internal structure of the Earth. Some of the vignettes have animations, videos, or short articles that will provide another perspective or visual explanation for the topic at hand. After reading the vignette and associated links, answer the following questions. Please note that some links might take a while to download based on your Internet speed.

GE.gifExpandthe **INTRODUCTION** folder and then check **Topic 1: Introduction**.

GE.gif Read Topic 1: **Introduction**

**Question 1:** What is one continent in which the there are two (or more) plates?

GE.gif Read Topic 2: **Continental Drift**

**Question 2:** What was discovered in Antarctica that solidified Wegener’s theory of continental drift?

GE.gif Read Topic 3: **Tectonic Landforms**

**Question 3:** Where do scientists think the next major ocean will be formed?

GE.gif Read Topic 4: **Human Interaction**

**Question 4:** List three reasons why humans are drawn to plate boundaries.

GE.gif Collapse and uncheck the **Introduction** folder.**GLOBAL PERSPECTIVE**

GE.gif Expand **GLOBAL PERSPECTIVE**. Double-click, and select, **Tectonic Plate Boundaries and Names** to display the names on the globe of the major tectonic plates.

Millions of humans live near the major tectonic plate boundaries. The potential dangers of living on or near a plate boundary include earthquakes, volcanoes and tsunamis. However, these natural hazards do little to discourage people from settling in these cities, especially if the region has economic, religious, political or social importance.

GE.gif Expand, and select, **Major Cities**. Double-click and select **Question 5**. When you arrive at your destination, find the information to fill in the blanks below. Choose the *two closest tectonic plates*. Repeat this for Questions 5 to 8.

**Question 5:** City: San Francisco

Two closest tectonic plates

Plate 1 name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Plate 2 name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Population: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 6:** City: Taipei, Taiwan

Two closest tectonic plates

Plate 1 name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Plate 2 name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Population: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 7:** City: Jerusalem, Israel

Two closest tectonic plates

Plate 1 name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Plate 2 name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Population: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 8:** City: Karachi, Pakistan

Two closest tectonic plates

Plate 1 name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Plate 2 name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Population: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 9:** On what tectonic plate or plate boundaries do you live?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

GE.gif Collapse and uncheck the **GLOBAL PERSPECTIVE** folder.

**PLATE BOUNDARIES AND MOVEMENTS**

In general tectonic plate boundaries are classified as *converging*, *diverging*, and *transform*, while tectonic plate types are classified as either *oceanic* or *continental*. The following descriptions of plate boundaries and movements will help you answer Questions 10 to 23.

**Converging Boundaries**

|  |  |  |  |
| --- | --- | --- | --- |
| When an oceanic plate and a continental plate converge (Figure 1), the result is *subduction*, because the oceanic plate slides under the continental plate. Mountain ranges of volcanoes are created by magma from the melting oceanic plate rising to (and through) the continental crust. Deep oceanic trenches typically parallel the coast.  Description: GE.gif Expand the **PLATE BOUNDARIES** folder and then click **Subduction Animation** to view an animation of this type of convergence boundary. | Figure 1. Oceanic-continental convergence ([USGS](http://pubs.usgs.gov/gip/dynamic/understanding.html)). | | |
| Figure 2. Continental-continental convergence ([USGS](http://pubs.usgs.gov/gip/dynamic/understanding.html)). | | When two continental plates converge (Figure 2), compression and uplift occur at the boundary to form mountain ranges. Continental-continental convergence mountains are not comprised of volcanoes and thus contrast the orogeny of mountain ranges produced by oceanic-continental convergence. | |
| When two oceanic plates converge (Figure 3), one subducts under the other and the result is a deep ocean trench. In some cases, under sea volcanoes format these boundaries. Over millions of years, these oceanic-oceanic convergence boundaries produce volcanoes that reach the surface and form a chain of islands shaped in an arc. | | | Figure 3. Oceanic-oceanic convergence ([USGS](http://pubs.usgs.gov/gip/dynamic/understanding.html)). |

**Diverging Boundaries**

As the name implies, diverging boundaries occur where plates are moving away from each other. If the plates are oceanic, the result can be an underwater mountain range which follows the plate boundaries. If the plates are continental, the initial result is the creation of a valley or rift. Given enough time, these valleys or rifts might be submerged, forming long, narrow seas.

**Transform Boundaries**

Transform boundaries occur when two plates move horizontally past each other. The boundary, or *fault,* between the two plates can be several miles wide. Friction between the two plate boundaries can build up tectonic stress, which can be released instantaneously into the Earth’s crust in the form of an earthquake.

Description: GE.gif Expand the **Boundaries** folder, check the Plate Boundary folder, and then double‑click **Boundary A**.

Based on the descriptions of plate boundaries and movement provided, identify Boundaries A through G:

**Question 10:** Boundary a.gif \_\_\_\_\_\_\_\_\_

A. Continental-continental convergent B. Continental-oceanic convergent

C. Oceanic-Oceanic convergent D. Oceanic divergent

E. Continental divergent F. Transform

**Question 11:** Why did you choose this answer?

**Question 12:** Boundary b.gif \_\_\_\_\_\_\_\_\_

A. Continental-continental convergent B. Continental-oceanic convergent

C. Oceanic-Oceanic convergent D. Oceanic divergent

E. Continental divergent F. Transform

**Question 13:** Why did you choose this answer?

**Question 14:** Boundary c.gif \_\_\_\_\_\_\_\_\_

A. Continental-continental convergent B. Continental-oceanic convergent

C. Oceanic-Oceanic convergent D. Oceanic divergent

E. Continental divergent F. Transform

**Question 15:** Why did you choose this answer?

**Question 16:** Boundary d.gif \_\_\_\_\_\_\_\_\_

A. Continental-continental convergent B. Continental-oceanic convergent

C. Oceanic-Oceanic convergent D. Oceanic divergent

E. Continental divergent F. Transform

**Question 17:** Why did you choose this answer?

**Question 18:** Boundary e.gif \_\_\_\_\_\_\_\_\_

A. Continental-continental convergent B. Continental-oceanic convergent

C. Oceanic-Oceanic convergent D. Oceanic divergent

E. Continental divergent F. Transform

**Question 19:** Why did you choose this answer?

**Question 20:** Boundary F.gif \_\_\_\_\_\_\_\_\_

A. Continental-continental convergent B. Continental-oceanic convergent

C. Oceanic-Oceanic convergent D. Oceanic divergent

E. Continental divergent F. Transform

**Question 21:** Why did you choose this answer?

**Question 22:** Boundary G.gif \_\_\_\_\_\_\_\_\_

A. Continental-continental convergent B. Continental-oceanic convergent

C. Oceanic-Oceanic convergent D. Oceanic divergent

E. Continental divergent F. Transform

**Question 23:** Why did you choose this answer?

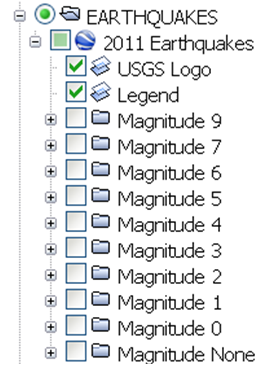
GE.gif Collapse and uncheck the **PLATE BOUNDARIES** folder.

**EARTHQUAKES**

When tectonic stresses from moving plates along boundaries and fault lines become too great, there can be a sudden release of energy which is manifested as an earthquake. The *foci* (where the earthquake originates) is often deep within the Earth’s lithosphere, while the epicenter, located vertically above the focus, is found at the Earth’s surface.

Earthquakes occur daily, yet we are not always able to feel them. Seismic waves (p and s waves) from the earthquake help triangulate the location of the epicenter by way of the Richter scale. The Richter scale measures the energy released by an earthquake. Because it is based on a logarithmic scale, an earthquake measuring 4.0 on the Richter scale releases 10 times the energy as compared to one measuring 3.0.

It is estimated that there are on average 130,000 earthquakes worldwide measuring between 3.0 and 3.9 each year (USGS, 2011). The most powerful earthquake recorded was in Valdivia, Chile in 1960, measuring 9.5 on the Richter scale. It generated a tsunami that traveled over 10,000 km across the Pacific Ocean, striking Japan and the Philippines with waves as high as 35 feet.

Description: Description: Description: GE.gif Expand the **EARTHQUAKES** folder, expand the **2011 Earthquakes** folder, and check only **USGS Logo** and **Legend** (Figure 4).

Within this folder are the locations, magnitudes (based on the Richter scale), and depths of all recorded earthquakes in 2011 (you might have to zoom in or zoom out to see the epicenters).

Description: Description: Description: Description: Description: GE.gif Double‑click the **Magnitude 9** folder.

Figure 4. Legend

**Question 24:** Where was the magnitude of 9 or higher recorded in 2011?

Description: Description: Description: Description: Description: GE.gif Uncheck the **Magnitude 9** folder, and then select double‑click the **Magnitude 7** folder.

**Question 25:** How many earthquakes with a magnitude between 7 and 7.9 were recorded in 2011?

**Question 26:** How many earthquakes with a magnitude of 7 or higher and a depth of 0-35 km were recorded in 2011?

Description: Description: Description: Description: Description: GE.gif Uncheck and then recheck the **2011 Earthquakes** folder. Verify that all boxes are checked (from **USGS Logo** to **Magnitude None**).

**Question 27:** Based on a visual inspection of the globe, which country experienced the most earthquakes in 2011? (you may have to zoom in/out)

**Question 28:** With respect to all earthquakes, most of them are located along the perimeter of the Pacific Ocean. What is this area - with its distinct pattern of earthquakes - known as?

Description: Description: Description: Description: Description: Description: GE.gif With the **2011 Earthquakes** selected and check the **Plate Boundaries** folder.

**Question 29:** Explain in a couple of sentences the spatial relationship between plate boundaries and earthquake epicenters.

GE.gif Collapse and uncheck the **EARTHQUAKES** folder.

**HOTSPOTS**

Description: GE.gif Expand the **HOTSPOTS** folder and then click **Hotspot Animation** to view an animation of this type of convergence boundary.

Description: GE.gif Select and double‑click **Seamount Chain** and **Kilauea**.

Most scientists believe that the Hawaiian Islands and the associated Hawaiian-Emperor Seamount Chain were created by a hotspot. A hotspot is a stationary location in the asthenosphere where a magma plume upwells and forms a *seamount* (an undersea volcano). If tectonic activity is sufficient, the seamount will grow, break the surface of the ocean, and eventually form an island.

Although the hotspot remains stationary, the overlying plate continues to move, resulting in a series of islands, *atolls* (coral islands with lagoons), and seamounts that show the movement of the plate over millions of years. Within this chain, the plate movement is evident as you move away from the Big Island of Hawai’i where the hotspot currently exists. At the end of the seamount chain is Meiji Guyot, created about 82 million years ago and considered by many to be the oldest seamount in the chain.

As the bend in the chain suggests, the Pacific plate has not always move at the same rate or in the same direction. Researchers theorize that about 43 to 50 million years ago, the Pacific plate changed direction and shifted from a northerly direction to a more westerly one. Currently, the Pacific Plate is moving in a northwest direction. And while the hotspot is currently under Kilauea on the Big Island of Hawai’i, it is also forming Li’iho Seamount, a new seamount about 35 km southeast from the Big Island.

Description: Description: Description: GE.gif In the Table of Contents, open the **Layers** pane, and verify **Borders and Labels** is selected. You might have to zoom in to see the labels of the islands.

**Question 30:** Using the ruler tool, what is the distance in miles from Kilauea to the center of Kauai? \_\_\_\_\_\_\_\_\_

Kauai was formed about 5.1 million years ago.

**Question 31:** Using the information above, calculate the average rate of speed (in inches per year, or in/yr) of the plate since the creation of Kauai? (Remember: Convert miles to inches: 63,360 inches = 1 mile). Show your work.

**Question 32:** Using the ruler tool, what is the distance in miles from Kilauea to the center of Maui? \_\_\_\_\_\_\_\_\_\_

Maui was created about 1.3 million years ago.

**Question 33:** Using the information above, calculate the average rate of speed (in inches per year, or in/yr) of the plate since the creation of Maui? (Remember: Convert miles to inches). Show your work.

**Question 34:** Do hotspots occur only in the ocean? Explain why or why not.

Description: Description: Description: GE.gif In the Table of Contents, go to the **Layers** pane, and uncheck **Borders and Labels**.

GE.gif Collapse and uncheck the **HOTSPOTS** folder.

**FAULT TYPES**

Description: Description: Description: Description: GE.gif Expand the **FAULT TYPES** folder and then click **Fault Types Animation** to view an animation.

Folding is the process by which rocks compress and deform. Several kinds of geologic structures are associated with this process, including anticlines, synclines, overturned fold, and overthrust faults.

Description: Description: Description: Description: GE.gif Double-click **Fly-over: Appalachian Mountains**.

Description: Description: Description: Description: GE.gif Close the animation control panel: 

Description: Description: Description: Description: GE.gif Double-click and select **Appalachian Mountains.**

This area of the Appalachian Mountains is known as the Ridge and Valley Province. The *geomorphology*, or spatial form and evolution of the land, consists of many ridges and valleys. *Anticlines* form most of the ridges in this area, while *synclines* make up many valleys. However, over millions of years, an inversion can occur in which structurally, synclines become ridges and anticlines become valleys. This is due in part to the erosion of softer rock by water over time. A resultant landform in these structurally inverted landscapes consists of steeply sloped ridges with sharp summits known as *hogback ridges,* which occur on each side of an anticline valley.

**Question 35:** Is Feature H.gif an anticline or syncline? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 36:** What is Feature I.gif which is located at the base of the Rocky Mountains? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 37:** Why did you provide the answer you did in Question 36?

Description: Description: Description: Description: GE.gif Double-click and select **Appalachian Mountains.**

Many geographers recognize four major faults – normal, reverse, overthrust, and strike-slip faults. In the following questions, answer and identify these types of faults. Where there is a series of normal faults, *horst* and *graben* can be found.

**Question 38:** What is the name of the cliff face formed by a normal fault? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 39:** What is Feature J.gif?: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 40:** What is Feature K.gif?: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 41:** What is the exposed side of Feature J.gif called?

**Question 42:** List 2 major differences between a reverse fault and an overthrust fault.

**Question 43:** What fault is not associated with uplift?

**Question 44:** How are strike-slip faults different from transform faults?

**Question 45:** Are faults limited to land, or can they occur under water as well? Explain why or why not.

**References**

USGS. 2011. <http://earthquake.usgs.gov/earthquakes/eqarchives/year/eqstats.php>. Accessed December 15, 2011.