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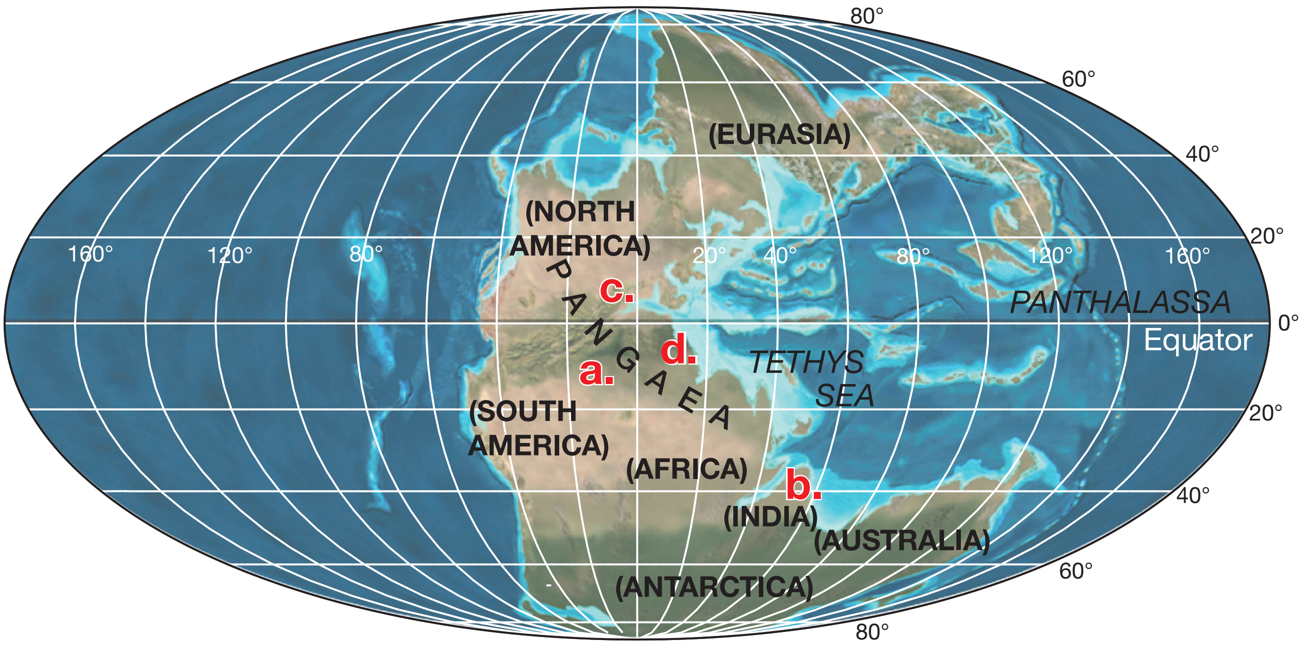
# LAB EXERCISE 19

# Plate Tectonics: Global Patterns

## Lab Exercise and Activities

## SECTION 1

### Plate Tectonics




▲ **Figure 19.1** Pangaea 200 to 225 million years ago

1. For b–d below, write the letter on Figure 19.1 at the appropriate location. The first location (a), has been marked as an example for you. You will need to use Figure 19.1 and the maps of world climates and biomes (found inside the back cover and outside the back cover of this manual) to find and mark:

   **a)** a location that was a desert (under the subtropical high) but is now a rain forest (tropical). Done for you.

   **b)** a location that would have been glaciated (Arctic or Antarctic) but is now tropical

   **c)** a location that was tropical but is now in the midlatitudes

   **d)** a location that was a rain forest (tropical) but is now a desert (under the subtropical high)

2. What physical clues and evidence prove that these landmasses were together 225 million years ago as Pangaea, and why do scientists think the continents are drifting (continent and sea-floor movements)?

   ***Geologic, fossil, and paleomagnetic evidence.***

3. If you were a petroleum geologist searching for oil deposits (derived from ancient biomass), why would you want to know the positioning of these landmasses hundreds of millions of years ago? What climate region would you look for?

   ***Petroleum deposits are generally associated with ancient plant communities. Knowing that equatorial latitudes are rich in photosynthetic communities fixing sunlight, it is important to find where landmasses were to identify where these deposits occurred. As the continents migrated after the breakup of Pangaea they carried these deposits with them and that is where the oil will be found today.***

4. In your opinion, what factors produced the long delay between the time of Wegener's lectures and book and the time of acceptance of his theory?

   ***Scientists at the time, knowing little of Earth's interior structure and bound by an inertial mindset as to how continents and mountains were formed, were unreceptive of Wegener's revolutionary proposal and, in a non-scientific spirit, rejected it outright. Aided by an avalanche of discoveries, the theory today is nearly universally accepted as an accurate model of the way Earth's surface evolves, and virtually all Earth scientists accept the fact that continental masses move about.***

5. Why did Wegener coin the name "Pangaea"? Explain its meaning.

   ***"Pan" means all, "Gaea" or "Gaia" was Earth Mother in pre-Hellenic and later mythologies, together they mean "all Earth."***

# SECTION 2

## Principal Motions of Plates and Plate Boundaries

1. At the time of Pangaea, South America and Africa were attached, forming a continuous landmass. Using Figure 19.2, describe what transpired in the past 225 million years to position the two continents where they are today.

   ***Sea-floor spreading created the Atlantic basin and ripped the two continents apart.***

2. With respect to the movement of crustal plates in the vicinity of the Andes Mountains: Why is the oceanic plate diving beneath South America? How is this related to the **orogenesis** (or formation of mountains) of the Andes? Explain.

   ***Sea-floor spreading is causing the Pacific Plate to subduct below the South American plate.***

Using a physical geography textbook, such as *Geosystems*, locate the plate names, examine the different rates of plate movement, and identify types of plate boundary interactions. Using this same source, complete the following questions.

**1.** Using colored pencils or colored pens, trace the plate boundaries on Figure 19.3 and color them as follows: convergent boundary–yellow; divergent–red; transform–blue.

**2.** Of the three types of plate boundary interactions shown in Figure 19.3, characterize the following plate boundaries:

**a)** On the ocean floor south of Alaska: ***subduction / convergence***

**b)** Indian Ocean between the Antarctic and Indo-Australian plates: ***divergent***

**c)** Beneath the Red Sea: ***rift / transform***

**d)** Along the west coast of Central America: ***subduction / convergence***

**e)** Through Iceland: ***sea-floor spreading / divergence***

**f)** Along the northeast coast of the Persian Gulf: ***collision crush zone / convergence***

**g)** In California between the Juan de Fuca plate and the North American plate: ***transform***

**3.** Which four plates converge on Japan?

***The Pacific, Philippine, and Eurasian plates.***

**4.** Mark your location on the map in Figure 19.3. On which plate do you live? (If you live west of the San Andreas fault system in California, take care with your answer.)

***Personal answer***

**5.** Google Earth™ activity, San Andreas Fault, CA. For the kmz file and questions, go to mygeoscience-place.com. Then click on the cover of *Applied Physical Geography: Geosystems in the Laboratory*. Or visit the Mastering Geography Study Area.

# SECTION 3

## Hot Spots and the Hawaiian-Emperor Island Chain

**1.** What is the distance from Midway Island to Lōʻihi, in kilometers? What is the difference between their ages? What has been the rate of movement of the Pacific plate, in centimeters per year, over this time frame?

[*The distance is approximately 2400 km. Midway is 27.7 million years old. Since 1 km equals 100,000 cm, 2400 km is equal to 240,000,000 cm. Since both the distance and age are in the millions, the math to find the rate of movement is 240 (distance in millions of centimeters)/27.7 (age in millions of years) = 8.6 cm/yr. The conversion from km to centimeters will come in handy in the next section as well.*]

**2.** What is the distance from the Detroit Seamount to the Koko Seamount, in kilometers? What is the difference between their ages? What has been the rate of movement of this region of the Pacific plate, in centimeters per year, over this time frame?

***1800 km. 32.9 my. Rate is 5.4 cm/yr.***

**3.** What is the distance from the Abbott Seamount to Lōʻihi, in kilometers? What is the difference between their ages? What has been the rate of movement of this region of the Pacific plate, in centimeters per year, over this time frame?

***3363 km. 38.7 my. 8.6 cm/yr.***

4. What is the distance from the Detroit Seamount through the Daikakuji Seamount to Lō'ihi, in kilometers? What is the difference between their ages? What has been the rate of movement of this region of the Pacific plate, in centimeters per year, over this time frame?

   ***5700 km. 81 my. 7.0 cm/yr***

5. Has the rate of movement of the Pacific plate been constant over the lifetime of the Hawaiian-Emperor island chain? Which section has been moving faster?

   ***It is moving more rapidly in the Abbott - Lo'ihi section.***

6. The oldest rock that makes up Lō'ihi is an estimated 400,000 years old. Using the rate of plate movement that you calculated in question 3, how far has it traveled since its first lava cooled?

   ***It has moved 8.6 cm × 400,000 yr = 34 km!***

7. What is the nature of the relative movement of plates and hot spots? Briefly explain which is fixed and which is moving. Also explain how the Hawaiian-Emperor island chain was formed. Part of being a scientist is questioning everything and testing everything. Thinking creatively, what are two possible reasons for the bend in the island chain? Briefly explain how you could test these two ideas.

   ***The Pacific plate is moving over the hot spot. The plume of magma has formed the Hawaiian-Emperor seamount chain as the plate has continued to move. The bend at Kimmei could have been caused by the movement of the plate changing or the plume itself moving. To test this, you could look at the motion of the plate at other locations between 48 and 27 mya.***

# SECTION 4

## Speeds of Plate Movement

1. Measure along the transect lines from the center of the ridge to the edge of the oldest full band and enter that data into **Table 19.1**.

**TABLE 19.1 Plate movement**

| Leg | Dist. km | Age my | Speed cm/yr |
|---|---|---|---|
| A to ridge | *1100* | *40* | *2.8 cm/yr* |
| B to ridge | ***1700*** | ***60*** | ***2.8 cm/yr*** |
| C to ridge | ***2900*** | ***120*** | ***2.4*** |
| D to ridge | ***2800*** | ***120*** | ***2.3*** |
| E to ridge | ***3200*** | ***80*** | ***4.0*** |
| F to ridge | ***2600*** | ***80*** | ***3.3*** |
| H to edge | ***2600*** | ***20*** | ***13.0*** |

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2. Enter the ages of the crust along each transect and calculate the speed of movement for each section in Table 19.1.
3. Are the three sections in the Atlantic that you measured moving at the same speed? Are both sides of the ridge moving at the same speed? Which section is moving the fastest?

   ***No. No. The southern Atlantic basin is moving more quickly.***
4. Compare the speed of the Atlantic sections with the Pacific transect. Which plate is moving more quickly?

   ***The Pacific is moving more than three times as fast as the Atlantic.***
5. What types of plate boundaries are on the Pacific and Atlantic shores of South America?

   ***There's a convergent plate boundary along the Pacific coast, and no plate boundary along the Atlantic coast.***