Name:______________________________________ Block:_______

Seafloor Spreading and Paleomagnetism Activity

Background: Some minerals in igneous rocks develop a slight magnetism in alignment with Earth's magnetic field at the time of their formation. Also, scientists have discovered the polarity of Earth's magnetic field has periodically reversed and the North Magnetic Pole becomes the South Magnetic Pole, while the South Magnetic Pole becomes the North Magnetic Pole. Putting these facts together provides additional support for plate tectonics. The ancient magnetism, called paleomagnetism, present in rocks on the ocean floor can be used to determine the rate at which the plates are separating and, consequently, the time when they began to separate. Where plates separate along the mid-ocean ridge, magma from the mantle rises to the surface and creates new ocean floor. As the magma cools, the minerals assume magnetism equal to the magnetic field at that time. As the plates continue to separate and Earth's magnetic field reverses polarity, new material forming at the ridge is magnetized in the opposite direction.

Scientists have reconstructed Earth's magnetic polarity reversals over the past several million years. A generalized record of these polarity reversals is shown in Figure 10.4. The periods of normal polarity, when a compass needle would have pointed North like today, are shown in color and labeled a-f. Use Figure 10.4 to answer the questions.

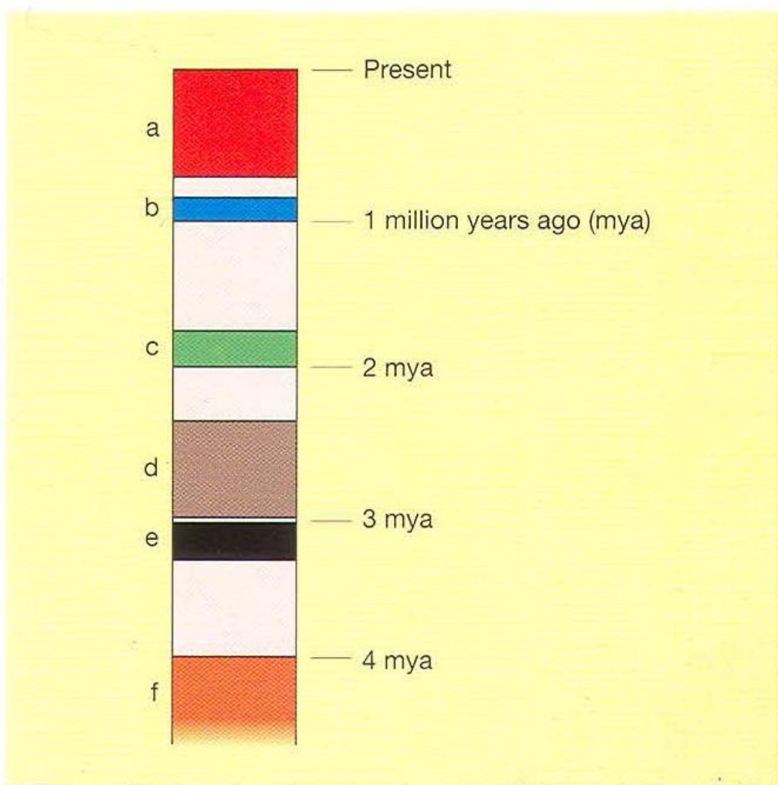

Figure 10.4 Chronology of magnetic polarity reversals on Earth during the last 4 million years. Periods of normal polarity, when a compass would have pointed North as it does today, are shown in color. Periods of reverse polarity are shown in white. (Data from Allan Cox and G. Dalrymple)

Questions for Figure 10.4:

1. The magnetic field of Earth has had (3, 5, 7) intervals of reversed polarity during the past 4 million years. Circle your answer.

2. Approximately how long ago did the current normal polarity begin? ________ years ago. One and a half million years ago, a compass needle would have pointed to the (North,South). Circle your answer.

3. The period of normal polarity, c, began (1, 2, 3) million years ago. Circle your answer.

4. During the past 4 million years, each interval of reverse polarity has lasted (more, less) than 1 million years. Circle your answer.

The records of the magnetic polarity reversals that have been determined from the oceanic crust across sections of the mid-ocean ridges in the Pacific, South Atlantic, and North Atlantic oceans are shown in Figure 10.5. As new ocean crust forms along the mid-ocean ridge, it spreads out equally on both sides of the ridge. Therefore, a record of the reversals is repeated. Notice that the general pattern of polarity reversals in Figure 10.4 can be matched with the polarity of the rocks on either side of the ridge for each ocean basin in Figure 10.5. Use Figures 10.4 and 10.5 to answer questions 5-7.

Questions for Figure 10.5:

5. Using the distance scale in Figure 10.5, the (Pacific, South Atlantic, North Atlantic) has spread the greatest distance during the last 2 million years. Circle your answer.

6. Refer to the distance scale in Figure 10.5. Notice that the left side of the South Atlantic basin has spread approximately 39 kilometers (km) from the center of the ridge crest in 2 million years.
   a. How many kilometers has the left side of the Pacific basin spread in 2 million years?_________________________ km
   b. How many kilometers has the left side of the North Atlantic basin spread in 2 million years? _________________________ km

The distances in question 6 are for only one side of the ridge. Assuming that the ridge spreads equally on both sides, the actual distance each ocean basin has opened would be twice (2 x) this amount.

7. How many kilometers has each ocean basin opened in the past 2 million years?
   a. Pacific Ocean basin _______ km
   b. South Atlantic basin _______ km
   c. North Atlantic basin _______ km

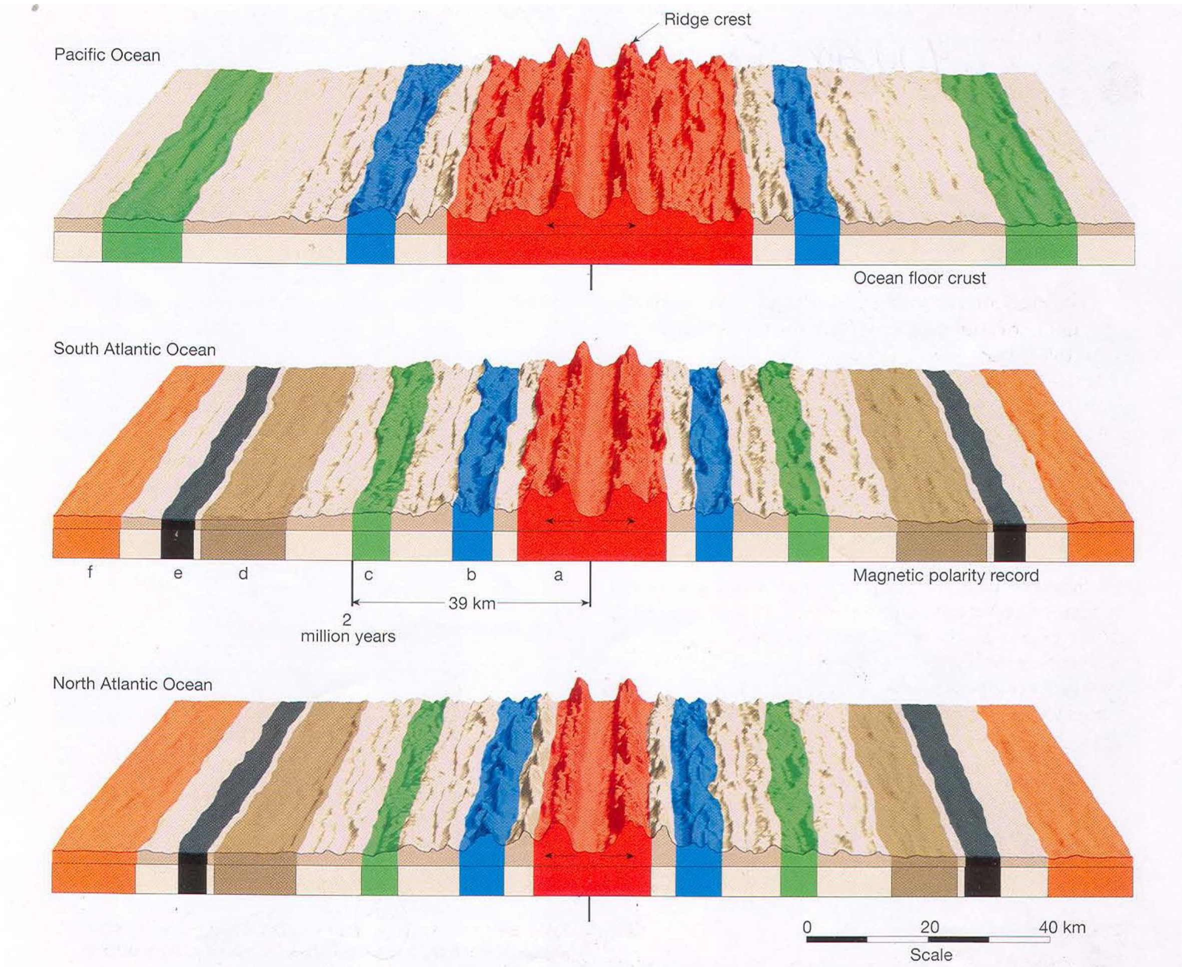

Figure 10.5 Generalized record of the magnetic polarity reversals near the mid-ocean ridge in the Pacific, South Atlantic, and North Atlantic oceans. Periods of normal polarity are shown in color and correspond to those illustrated in Figure 10.4.

If both the distance that each ocean basin opened and the time it took to open that distance are known, the rate of **seafloor spreading** can be calculated. To determine the rate of spreading in centimeters per year for each ocean basin, first convert the distance the basing has opened (from question 7) from kilometers to centimeters and then divide this distance by the time which is 2 million years.

8. Determine the rate of seafloor spreading for the Pacific and North Atlantic basins. The South Atlantic has already been done.
    a. South Atlantic: distance =78km x 100,000 cm/km = 7,800,000 cm
       Rate of spreading = 7,800,000cm / 2,000,000yr = 3.9 cm/yr

    b. Pacific distance ________________km x 100,000 cm/km = _________________cm

       Rate of spreading = _______________cm / Yr = _______________cm/yr

    c. North Atlantic distance ______________km x 100,000 cm/km = ____________cm

       Rate of spreading =_________________cm / yr = _______________cm/yr

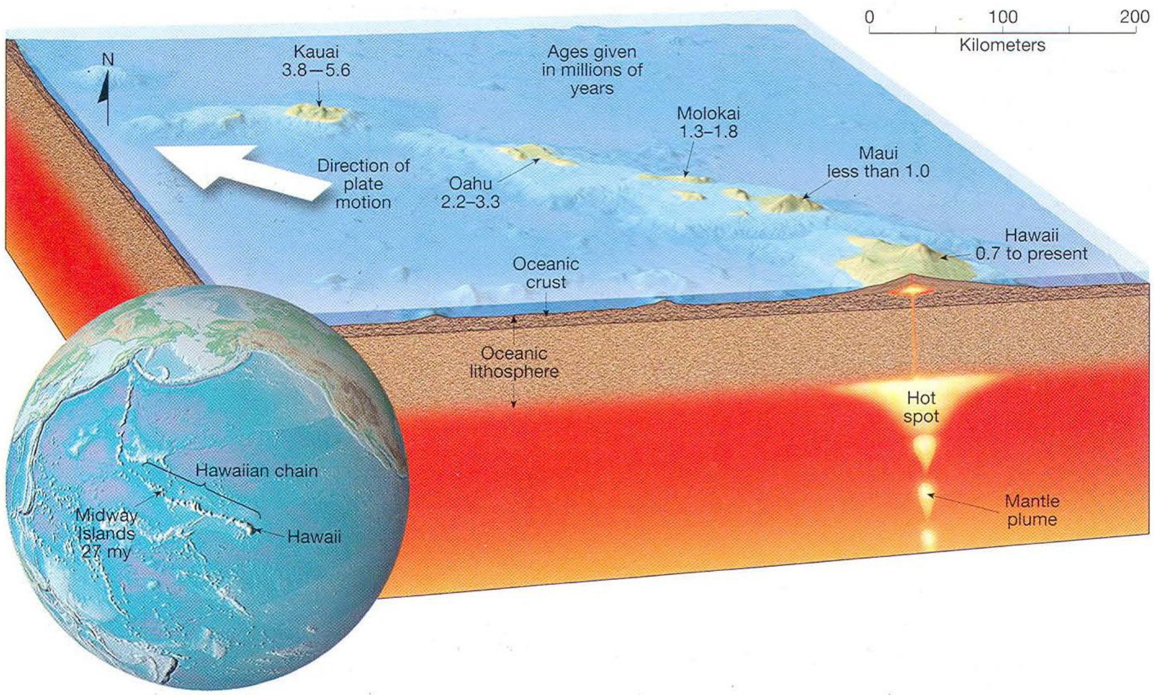

Figure 10.6 Movement of the Pacific plate over a stationary hot spot and the corresponding radiometric ages of the Hawaiian Islands in millions of years.

Researchers have proposed that a rising plume of mantle material has formed a hot spot below the island of Hawaii (Figure 10.6 above). It is believed that the position of this hot spot within the Earth has remained constant during a very long period of time. In the past, as the Pacific plate has moved over the hot spot, the successive volcanic islands of the Hawaiian chain have been built. Today the island of Hawaii is forming over this mantle plume. Radiometric dating of the volcanoes in the Hawaiian chain has revealed that they increase with age with increasing distance from the island of Hawaii. Knowing the age of an island and its distance from the hot spot, the velocity of the plate can be calculated. Velocity is equal to distance divided by time. (V=d/t) Use Figure 10.6 to answer questions 9-11.

9. What are the minimum and maximum ages of the island of Kauai?

   Minimum _________________ million years

   Maximum _________________ million years

10. What is the distance of Kauai from the hot spot in both kilometers and centimeters?

    _____________________ kilometers

    _____________________ centimeters (cm = km x 100,000 cm/km)

11. Using the data in questions 9-10, calculate the approximate maximum and minimum velocities, in centimeters per year (cm/yr), of the Pacific plate as it moved over the Hawaiian hot spot.

    Maximum velocity _________ __________cm/yr

    Minimum velocity ____________________ cm/yr