GEOL 106: Earthquake Country
Online Activity 2: Plate Motions and Plate Motion Rates

Name _____ Date: _____

Part 1: Tectonic Plate Spreading Rates

We can calculate an average rate of seafloor spreading by measuring the distance between Mid Ocean Ridges, then divide the distance by the age of seafloor rocks collected there (e.g. such as from ODP cores).

Recall: Rate (r) = Distance (d) ÷ Time (t) or r = d / t

We can make measurements on a map, but those are not the real distances, but map distances. We need to convert these map distances to real world distances by using a map scale conversion ratio. We can determine the scale of a map by comparing a "Map Distance" (MD, a measurement we make on a paper map with a ruler) with the "Real World Distance" (RWD, the real distance between two objects) of that same measurement. On a map, we can find a location with a known RWD and then take a measurement with a ruler. We then make a ratio of those measurements like this: RWD/MD. If we multiply a given MD by this ratio, the answer will be in RWD units.

Let's say that you determine the map scale ratio is 10°/17 mm and that the MD distance between two objects is 25 mm. When you then multiply this MD by your map scale ratio, you get the following calculation: (25 mm)X(10° /17 mm)= 14.7°. Typically we would then need to convert this to kilometers for example. In our examples below, 1° = 60 Nautical Miles (NM) and 1 NM = 1.852 kilometers (km). So we would write the following equation: (14.7°)X(60 NM/1°) = 882 NM and then (882 NM)X(1.852 km/1 NM) = 1,634 km. In other words, the objects that were 25 mm apart on the map are really 1,634 km apart in the real world. Note how the units cancel each other. When there is a unit (e.g. NM) in the numerator and the denominator, they cancel each other out.

(1) 5 pts (Mid Atlantic Ridge Spreading Rate Calculation): What is the average half spreading rate of the Atlantic Ocean basin measured along the Equator? Use the distance between the Mid Atlantic ridge and the outer edge of the continent of Africa to determine the edge of the oceanic plate. Measure the distance along the equator, where 1° of longitude = 60 NM.

You will need to convert your "Map Distance" to "Real World Distance." Use the distance between Longitude marks to determine the ratio of RWD/MD that you will use. I suggest you make your measurements in millimeters (mm). First measure the distance between the marks, this is your MD. The RWD distance between these Longitude marks is 10°. You can now make your RWD/MD ratio. Remember to label the units in your calculations. Measure the distance between the Mid Atlantic ridge and the coast of Africa in mm. Now multiply that measurement by your RWD/MD ratio. This is your RWD distance for your rate calculation.

The oldest ocean floor, basalt rocks collected at the base of the continental shelf are mid-Cretaceous in age. Use the GSA geological time scale to estimate the age, in Ma, of the mid Cretaceous (take an average of the beginning and the end of this time period). This is your time calculation. (**Show your calculations below**)

(2) 5 pts (East Pacific Rise Spreading Rate Calculation): What is the average half spreading rate measured from the Mid Ocean Ridge to the continental margin of the western Pacific Ocean basin along the Equator? Measure from the <u>East Pacific Rise</u> to the continental margin in the western Pacific Basin. The oldest seafloor, basalt rocks collected here are mid-Jurassic in age. (**Show your calculations below**)

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Part 2: Tectonic Plate Motion Rates

You now can synthesize your knowledge of charts, map scales, and plate tectonics to determine rate of plate movements. You will need a ruler and a calculator to make the 7 separate calculations (one for each of the Hawai'ian or Emperor Seamounts listed below). The radiometric age for each island or seamount is given in Ma, of Millions of Years. Show your work on a separate piece of paper and put your final answers in the Table below.

(3) 5 pts (Pacific Plate Motion Calculation): Calculate the average rate of seafloor movement of the Pacific plate over the Hawai'ian Hot Spot using the radiometric age of the volcanic islands with respect to the distance from the active Hawai'ian Island shown One strategy to complete this is as follows:

1) Use latitude to determine the scale of the chart. To determine the scale, use a ruler to measure the distance on the chart (in mm) of 10° latitude. Since 1° latitude = 60 Nautical Miles, then 10° (of latitude) = 600 NM. Convert 600 NM to mm (using your RWD/MD conversion factor). Conversion Factors: 1 NM = 1.852 km; 1 km = 1,000,000 mm

2) Measure the distance between the Big Island of Hawaii and each of the successive older islands in the chain using the ends of the label lines. Use the end of the label lines to make your measurements.

3) Use the fractional scale to convert these to "real world" distances.

4) Divide the "real world" distance to the each island by the age shown and determine the rate of plate movement for each time period (e.g. 2 to 10 Ma, 10 to 20 Ma, etc.). Remember that 1 Ma = 1,000,000 years.

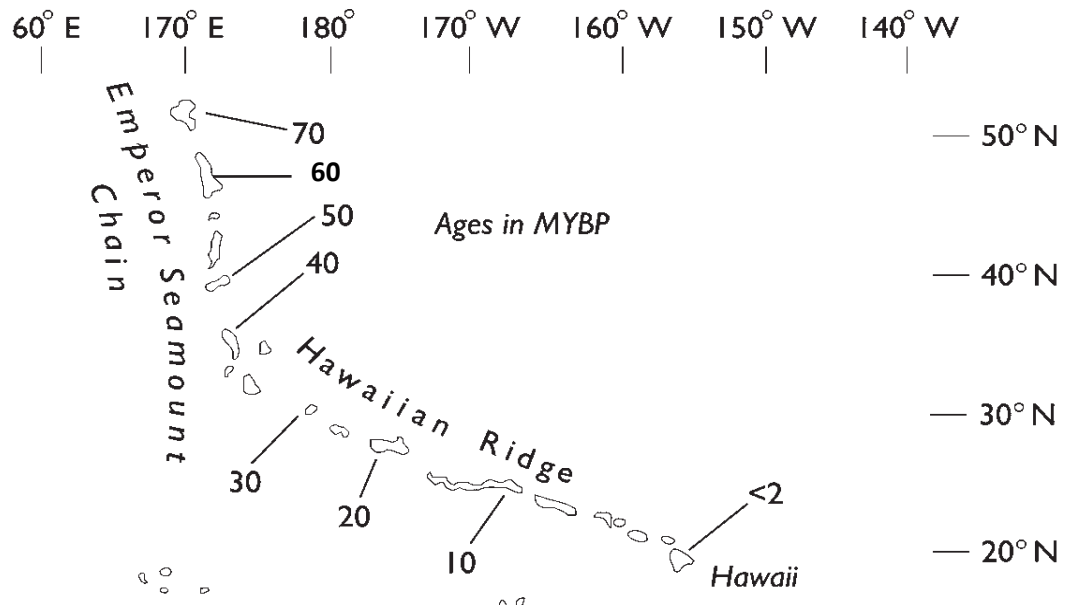5) Show your calculations on a separate piece of paper and place your final answers in the table below.

Figure 1: A chart showing maximum radiometric age dates and the distance from the active modern hot spot island of Hawai'i.

6) **(4) 4 pts (Sediment Thickness Calculation):** Assume sediments accumulate on the sea floor at the rate of 2 mm per 1,000 years (2 mm/1000 yr). What is the expected thickness of the sediment cover for each of the 7 seamount ages listed (e.g. 10 Ma, 20 Ma, etc.) up to the oldest seamount. Put your answers in the table below and show your work below or on a separate sheet. A hint is that you can restructure the rate formula to solve this problem and that the sediment thickness can be considered a distance. So, r = d/t can be rewritten to be d = r X t.

(5) 1 pt (Map Scale Determination): Determine the Relative Fraction (RF) scale of the map of Hawaiian Islands and Emperor Seamounts. This is typically stated in the format 1:xx,xxxx, where 1 unit on the map is equal to xx,xxxx units in the real world. If the RF scale is 1:24,000 it means that 1 mm on the map is 24,000 mm in the real world. Take your MD/RWD conversion ratio and reformulate it so that there is a 1 in the numerator. The denominator will be the relative fraction scale of the map.

Scale: _____

AGE (Ma.)	1) Rate of Seafloor Movement (mm/yr)	2) Sediment Thickness (m)
10 Ma		
20 Ma		
30 Ma		
40 Ma		
50 Ma		
60 Ma		
70 Ma		