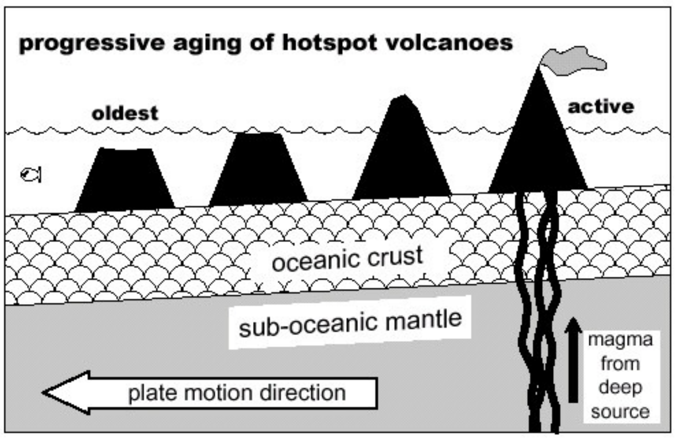
Name: ____

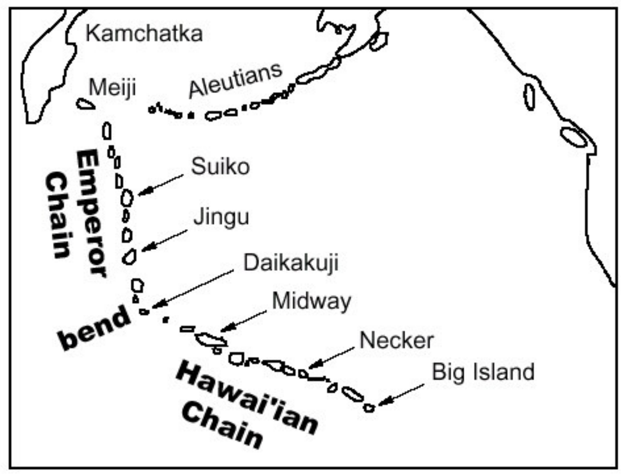
Geology 1: Hawaiian-Emperor Seamount Exercise

Objective: to discover some of the aspects of plate tectonics by examining real data.

Background:

The Hawaiian-Emperor seamount chain stretches for 6,000km across the Pacific Ocean. This string of more than 100 volcanoes was formed as the Pacific plate slid across a hot spot (or mantle plume) in the asthenosphere below. Some of these volcanoes extend above sea level to form islands while others are submerged seamounts. Over time the volcanoes erode, cool and subside below sea level often forming flat-topped guyots.





Procedure:

Step 1: Plot the age-distance data

To better understand this process we will plot the age-distance relationship of 30 volcanoes listed in Table 1 on the graph provided. Mark a "**+**" at each volcano's age-distance point. **USE PENCEL** so you can correct mistakes. Give the plot a descriptive title and label each axis so that someone seeing the graph for the first time could understand what it represents.

Step 2: Interpret the data

1) Draw a straight line that best fits (is closest to) all the data points. The <u>slope</u> of this line represents the average <u>rate</u> at which the plate is moving (in km/Ma). Note that the points do not all lie <u>on</u> the line. Give some reasons why all the points don't lie exactly on the line.

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2) Calculate the rate (distance/time) at which the Pacific plate is sliding across the hot spot.

   a. First determine the slope of the line. If you don't know how to do this see page 4.

      Plate rate = ____________________________ km/Ma

   b. The answer above is in units of km/Ma. Geologists typically measure plate motions in units of cm/year. Convert the value above to cm/yr. See page 4.

      Plate rate = ____________________________ cm/yr

      In what direction is the Pacific plate moving? ___________________________

3) Try fitting the data better by putting a bend in your line thus drawing two lines with

   different slopes. How long ago would the bend have happened?_____________________

   What caused the bend?____

4) Examine the map on the first page of the exercise. Note that there is a bend in the seamount chain on the map.

   How do you explain this? ____

   ____

   When did this happen? ____

5) How old is the oldest volcano in the chain? __________________________________ yrs

   The creation of the Hawaiian-Emperor seamount chain represents what percentage of the

   earth's whole history? ________________________________%

Questions to ponder:

- Are there other island chains similar to this one?
- Why does the chain stop at Meiji?
- Why do geologist think the plate is moving and not the hot spot?
- How long does an island in the chain last?
- Where will the next island be?

This exercise is based on data from Clague and Dalrymple (1989) found at:
www.seattlecentral.org/qelp/sets/073/073.html

Table 1: Volcano Age and Distance from Hawaiian Hot Spot

(data source: http://www.seattlecentral.org/qelp/sets/073/073.html)

volcano number	volcano name	age (Ma)	distance (km)	*age error (Ma)*	*dist. error (km)*
1	Kilauea	**0.20**	**0**	*0.20*	*1.5*
3	Mauna Kea	**0.38**	**54**	*0.05*	*1.8*
5	Kohala	**0.43**	**100**	*0.02*	*2.0*
6	East Maui	**0.75**	**182**	*0.04*	*2.5*
8	West Maui	**1.32**	**221**	*0.04*	*2.7*
10	East Molokai	**1.76**	**256**	*0.07*	*2.9*
11	West Molokai	**1.90**	**280**	*0.06*	*3.0*
13	Waianae	**3.70**	**374**	*0.10*	*3.5*
14	Kauai	**5.10**	**519**	*0.20*	*4.2*
15	Niihau	**4.89**	**565**	*0.11*	*4.5*
17	Nihoa	**7.20**	**780**	*0.30*	*5.6*
20	unnamed 1	**9.60**	**913**	*0.80*	*6.3*
23	Necker	**10.30**	**1058**	*0.40*	*7.1*
26	La Perouse	**12.00**	**1209**	*0.40*	*7.9*
30	Gardner	**12.30**	**1435**	*1.00*	*9.1*
36	Laysan	**19.90**	**1818**	*0.30*	*11.1*
37	Northampton	**26.60**	**1841**	*2.70*	*11.3*
50	Pearl & Hermes	**20.60**	**2291**	*0.50*	*13.6*
52	Midway	**27.70**	**2432**	*0.60*	*14.4*
57	unnamed 2	**28.00**	**2600**	*0.40*	*15.3*
63	unnamed 3	**27.40**	**2825**	*0.50*	*16.5*
65	Colahan	**38.60**	**3128**	*0.30*	*18.1*
67	Daikakuji	**42.40**	**3493**	*2.30*	*20.0*
72	Kimmei	**39.90**	**3668**	*1.20*	*20.9*
74	Koko	**48.10**	**3758**	*0.80*	*21.4*
81	Ojin	**55.20**	**4102**	*0.70*	*23.2*
83	Jingu	**55.40**	**4175**	*0.90*	*23.6*
86	Nintoku	**56.20**	**4452**	*0.60*	*25.1*
90	Suiko 1	**59.60**	**4794**	*0.60*	*26.9*
91	Suiko 2	**64.70**	**4860**	*1.10*	*27.2*

Ma = Mega annum (million years ago)
Volcano Number is the volcano's number in the chain counting NW from the hot spot not all volcanoes are on this list. The last two columns are estimates of the errors in the first two columns.

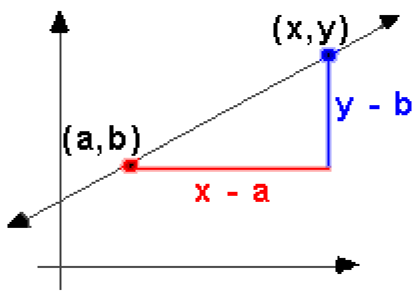
Don't panic! This is elementary school math.

How to draw a "best fit" line

Place a straight edge through the points and adjust its slope until it is as close as possible to all the points. There should be an equal number of points above and below the line.

How to calculate slope

By definition, slope is the ratio of the vertical change in a line to the horizontal change. In the figure below the sloping line is defined by two points (a,b) and (x,y).



The vertical change is equal to **y - b** and the horizontal change is equal to **x - a**.
The slope, ***m,*** is therefore equal to:

$$m = \frac{y - b}{x - a}$$

How to convert from km/Ma to cm/yr

The rate you calculated from the raw data will be in the units of kilometers (km) per million years (Ma). However, geologists routinely report the rate of plate motions in centimeters (cm) per year. So you must convert the rate to cm/yr with the following conversion:

$$\frac{\textbf{km}}{\textbf{Ma}} \times \frac{\textbf{1000 m}}{\textbf{km}} \times \frac{\textbf{100 cm}}{\textbf{1 m}} \times \frac{\textbf{1 Ma}}{\textbf{1,000,000 years}} = \frac{\textbf{cm}}{\textbf{year}}$$

Title: ____

Y-axis ______________________________

X-axis ____