

**89.582 - GEOLOGICAL OCEANOGRAPHY  
HOMEWORK 1 -GEOMAGNETISM AND CONTINENTAL DRIFT**

**I. Introduction**

The earth's magnetic field can be viewed as a simple bar magnet located near the center of the earth and inclined from the geographic axis (Figure 1). The actual position of the magnetic pole changes with time due to drifting of the magnetic field.

The north seeking end of a compass points towards the magnetic north pole (which must, therefore, be the south magnetic pole of our simple bar magnet), and the needle generally points either to the east or west of the geographic north pole. This east or west deviation from true north is called *magnetic declination* - the angular variation between the geographic north pole and the magnetic north pole. Only in two special cases will true north and magnetic north correspond, a point to keep in mind when you are using a compass.

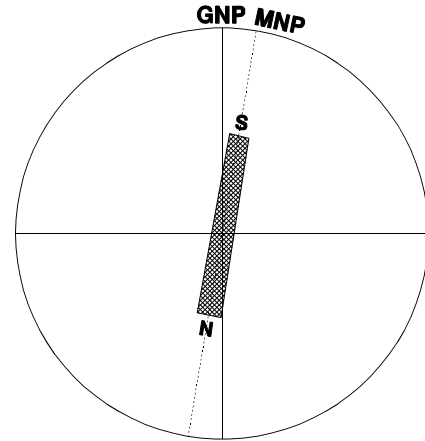
**II. Polar Wandering**

If you cover a bar magnet with a piece of paper and gently sprinkle iron filings on the paper, the iron filings will align parallel to the magnetic field lines and thus show the shape of the magnetic field. The magnetic field lines are curved. A similar situation exists with respect to the earth's magnetic field (Figure 2). Notice that the angle the magnetic field makes with the earth's surface varies with latitude. This variation is referred to as *inclination*. If we make the assumption that the magnetic and geographic poles are at the same location (an assumption which is true when the position of the earth's magnetic field is averaged over thousands of years), latitude and inclination can be related by the simple formula

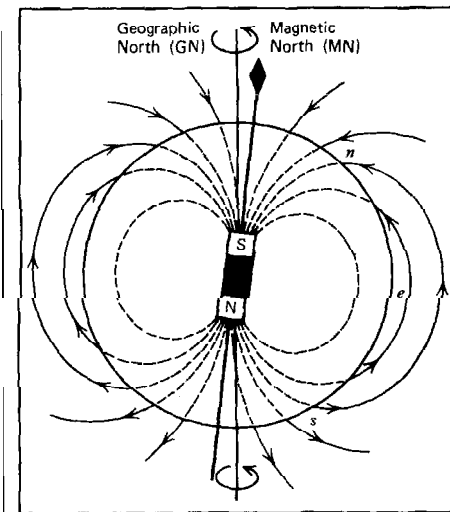
$$\tan \delta = 0.5 \tan i \quad (1)$$

where  $\delta$  = latitude and  $i$  = inclination.

Using the data given in Table 1, on the following graph plot inclination as a function of latitude.



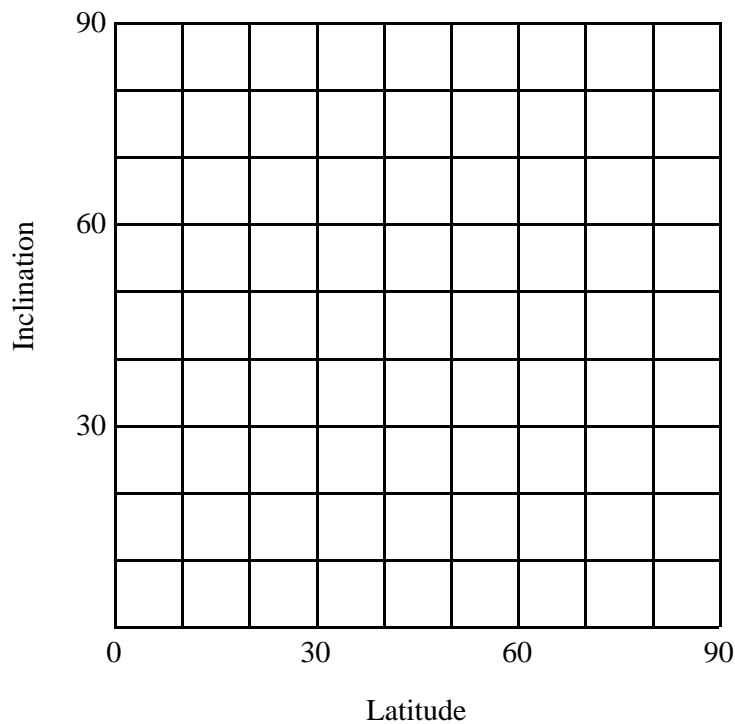
**Figure 1.** Representation of the earth's magnetic field as a simple bar magnet. The magnetic field is inclined with respect to the earth's rotational axis.



**Figure 2.** Lines of magnetic flux for the earth's magnetic field. From Wyllie, P. J., 1976. *The Way the Earth Works*. New York: John Wiley & Sons, Inc., p. 105.

**Table 1. Latitude vs inclination of the earth's magnetic field**

Latitude	Inclination
90N	90°
75	82
60	74
45	64
30	49
15	28
0	0



Certain minerals in a rock (particularly magnetite) are magnetic and their magnetic field is aligned with the magnetic field of the earth at the time the mineral is formed. It is possible to take a rock sample into the laboratory, artificially cancel out the earth's existing magnetic field, and measure the remnant magnetic field caused by these minerals. This remnant magnetism is referred to as paleomagnetism.

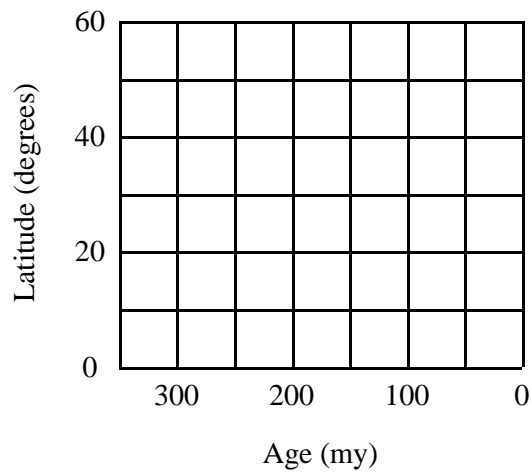
You are a geologist and have been busily at work collecting rocks of different ages from two continents, A and B. You take the samples into the laboratory and determine the fossil magnetic inclination. The data you collected are tabulated in Table 2. For each sample, calculate the paleolatitude at the time it was formed using

either the inclination versus latitude curve or equation 1.

**Table 2. Paleomagnetic inclination (in degrees) for Continents A and B**

Continent A				Continent B		
Age (my)	i	$\delta$		Age (my)	i	$\delta$
0	64			0	35	
50	60			50	25	
100	45			100	20	
150	30			150	15	
200	10			200	10	
250	10			250	10	
300	0			300	5	
350	0			350	10	

On the graph below plot the positions of the two continents as a function of time. Use a different color for each continent.

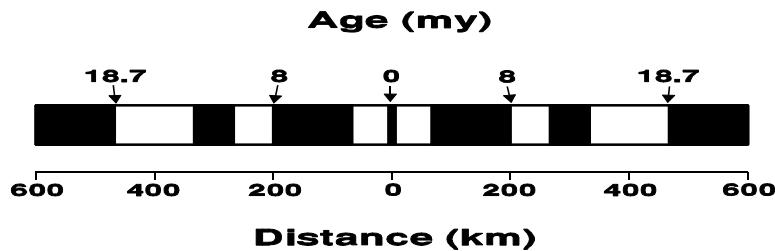


1. How might you interpret the latitude versus age data? Geologists were very surprised when they first made this discovery in the 1950's.

### III. Magnetic Reversals and Sea Floor Spreading

The greatest mountain chain on earth, 40,000 miles long, exists under the oceans. This mountain chain is referred to as the mid-ocean ridge system. Geologists discovered in the early 1960's that if you towed a magnetometer (a device that measures the intensity of the earth's magnetic field) across the ocean's surface perpendicular to a mid-ocean ridge, the intensity of the earth's magnetic field varied in a regular manner. In fact, the variation in intensity was symmetrical about the mid-ocean ridge. It was also discovered that the polarity of the earth's magnetic field reverses through geologic time. It was suggested that the observed variations in magnetic intensity were due to sea floor rock that were formed at different times. If a particular piece of sea floor was formed when the magnetic polarity of the earth's field was the same as it is today (*normal polarity*) the measured magnetic field would be *anomalously high*. If a particular piece of sea floor was formed when the magnetic polarity of the earth's field was opposite from what it is today (*reversed polarity*) the measured magnetic field would be *anomalously low*. Using radiometric dating techniques it was possible to determine the age of the various magnetic anomalies.

Figure 3 shows the pattern of magnetic anomalies for ocean X. Open areas represent normal polarity, shaded areas represent reversed polarity.



**Figure 3.** Sea-floor magnetic anomalies as a function of distance from the center of the mid-ocean ridge and age.

2. How did Vine and Matthews interpret the observed magnetic anomaly patterns?

3. Calculate the rate of sea-floor spreading between 0 and 8 my and between 8 and 18.7 my. Are the spreading rates constant?

4. What is the age of the sea-floor located 1000 km from the mid-ocean ridge.

5. What does all of this suggest to you about the positions of continents? Are these positions fixed?