Geological Sciences 107: Plate Tectonics

Lab Exercise #5: Seafloor Spreading and Magnetic Anomalies

Name ___________________________

Introduction

Magnetic Anomalies on Oceans

In the oceans, we measure the magnitude of the magnetic field by towing a magnetometer behind a ship. The magnitudes are combinations of two sources: Earth's present magnetic field and remanent magnetism of rocks on the ocean floor. To gain information about the the remanent magnetization of ocean floor, we subtract the regional value of the Earth's magnetic field from the International Geomagnetic Reference Field (IGRF). What remains is the magnetic anomaly. Magnetic anomalies exhibit alternating stripes of positive and negative magnitudes parallel and symmetric about the axes of the midocean ridges. Given the Earth's magnetic field reverses throughout the geologic time scale and that rocks record the Earth's magnetic field when they cool, this observation can be explained by sea-floor spreading.

Explanations

Due to accessibility of rocks on islands and continents, the age and the magnetic orientation of rocks can be determined simultaneously. Thus, a time scale of geomagnetic reversals (Figure 1) was established. If a rock formed at the time of normal polarity, it is magnetized in a orientation similar to the Earth's present magnetic field and exhibits a positive anomaly. Conversely, rocks formed during a reversed magnetic field exhibit negative anomalies. Furthermore, time scales established from islands and continental rocks correlate quite well with the magnetic anomalies observed in the oceans. The correlation between two independent observations is strong evidence to support sea-floor spreading.

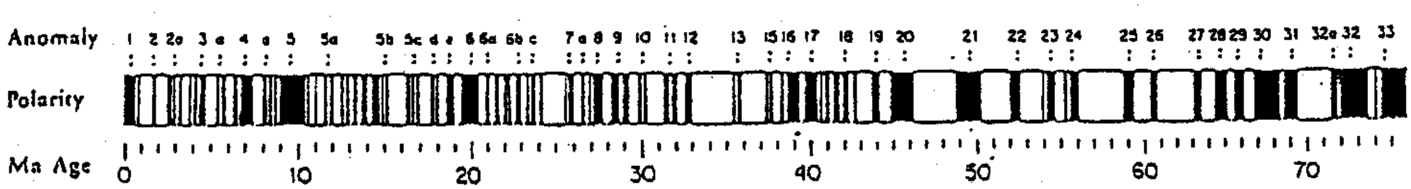


Figure 1. Magnetic time scale. Magnetic anomaly identification numbers are given and an absolute time scale in millions of years (Ma) is given. Normal magnetic anomalies are shown in black and reversed polarity is shown in white. The absolute age of the anomalies. The absolute age of the anomalies and their polarities can be read directly from the chart. For example, anomaly 4 is 7 million years old, and it is a positive anomaly.

Part 1

Figure 2 is a map of part of the eastern Pacific Ocean, showing the mid-ocean ridge (called East Pacific Rise) as a heavy black line. It is offset between several fracture zones (FZs). The mid-ocean ridge is the divergent boundary between the Pacific and Nazca plates. The numbered lines on each side of the ridge are magnetic anomalies. The age of each anomaly is known from the magnetic time scale (Figure 1).

1. Determine the ages of anomalies 2, 3, and 5a from figure 1 and record in the table in the *Age* column.

2. Measure the distance between each pair of anomalies of the same age on the south wall of the Garrett fracture zone (Figure 2); use bar scale for distance; record in the table under *Distance* column for East Pacific Rise.

3. Using the graph, plot points of age and distance and draw straight lines through points; label this line East Pacific Rise.

4. Figure 3 shows the mid-ocean ridge of the Atlantic Ocean - the Mid-Atlantic Ridge; measure distances and ages of all anomalies along the Ascension Fracture Zone, and record in the table; anomaly 13 is shown on one side only - measure 13 to the Mid-Atlantic Ridge and double this distance.

5. Plot points and a line on graph; label Mid-Atlantic Ridge.

6. Calculate spreading rates for the two mid-ocean ridges.

East Pacific Rise: km/my = ____________ mm/year

Mid-Atlantic Ridge: km/my = ____________ mm/year

Figure 2.

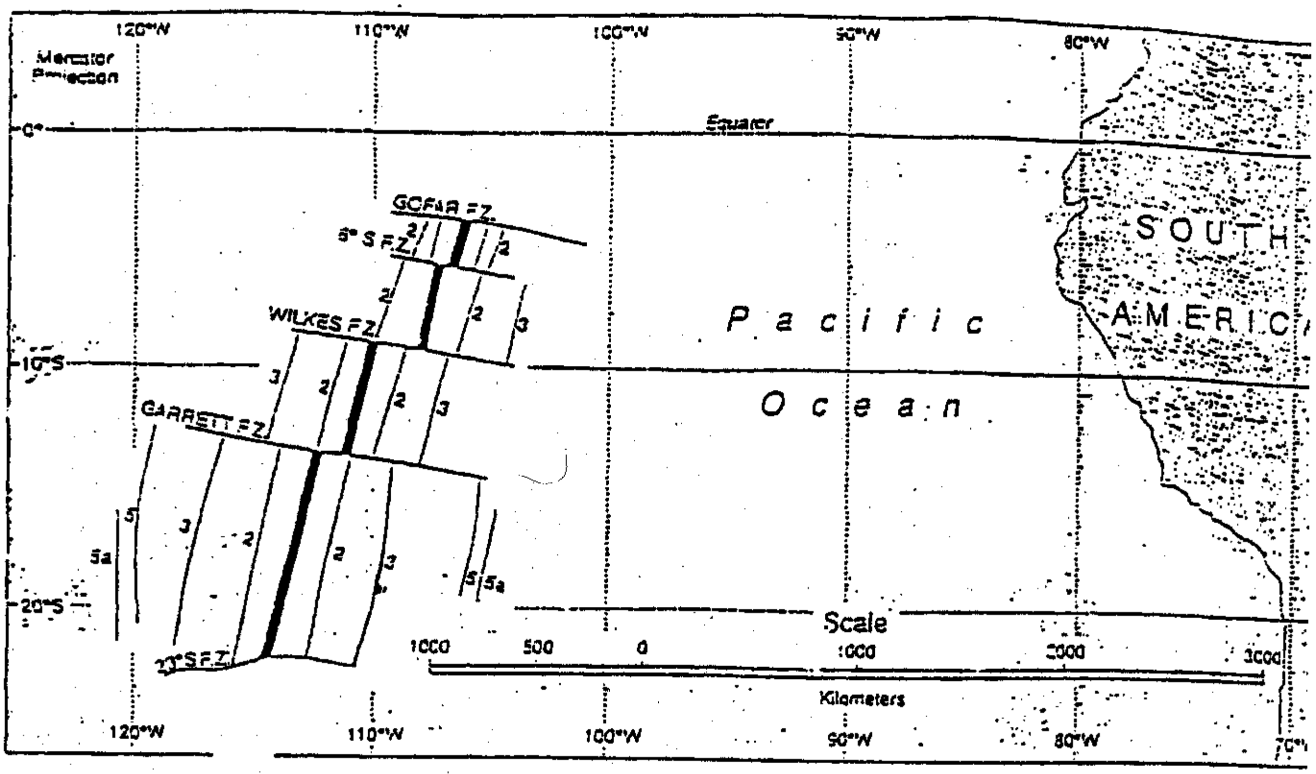
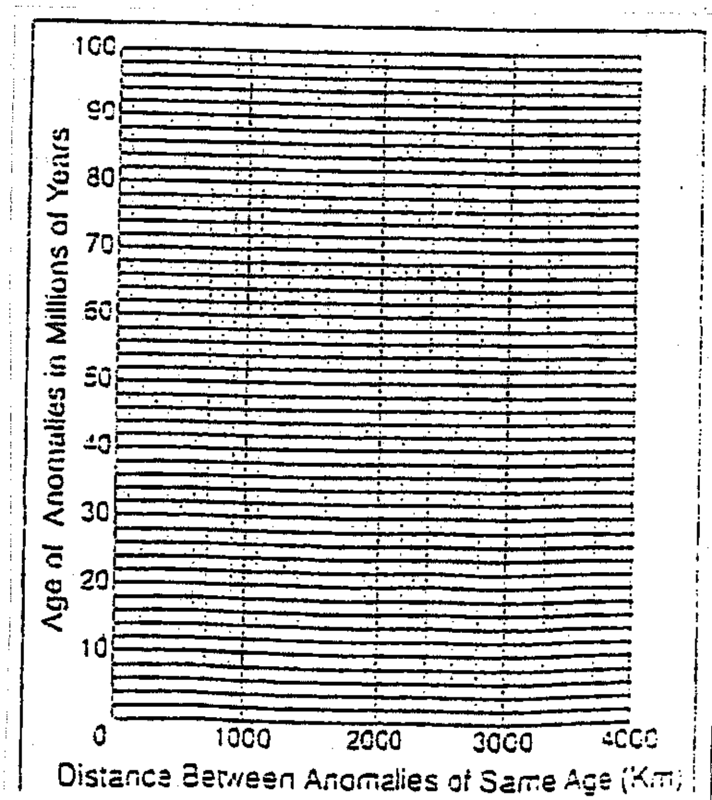


Table and graph paper to plot your resutlts

Anomaly Number	Age in Millions of Years	Distance Between Anomalies in Km	
		East Pacific Rise	Mid-Atlantic Ridge
2			
3			
5			
5a			
8			
13			
21			



Instructions for Part I, #7

For this exercise, we will use anomaly 21. The magnetic time scale indicates 21 formed at 50 million years ago.

Proceed as follows:

1. On the map, draw a red line over each segment of magnetic anomaly number 21 on the South American side of the Mid-Atlantic Ridge. Connect the segments of the number 21 anomaly with a red line drawn along the fractures zones against which they terminate. Start with the point where anomaly 21 touches the Ascension F.Z. Follow anomaly 21 with your red pencil southward until it reaches the Bode Verde F.Z., then along the Bode Verde F.Z. westward to the northern end of the next fracture zone. Continue until you have reached the southernmost fracture zone on the map.

2. Attach a piece of tracing paper over the map with tape or paper clips, and repeat the process described above for anomaly 21 on the African side of the Mid-Atlantic Ridge. Draw this line in red on the tracing paper.

3. With the tracing paper still inplace, trace the coastlines of Africa and South America on the tracing paper with a black pencil. Also, trace on the tracing paper the boundaries of the map and the 20 degrees South latitude line in black.

4. Detach the tracing paper and slide it toward South America parallel to the Fracture Zones until the red line on the tracing paper matches the red line on the map. When the two lines are matched as closely as possible, hold the tracing paper in place and trace the coastline of South America in red pencil.

5. The map you have constructed on the tracing paper shows the Mid-Atlantic Ridge as it existed when magnetic anomaly 21 was being formed. Your tracing paper also shows the relative position of segments of the coastlines of Africa in black pencil and South America in red pencil as they were approximately 50 million years ago. This reconstruction is based on the assumption that the *continents* of Africa and South America were fixed to their respective plates during the spreading process over the past 50 million years. The *continents* moved with respect to each other because the *tectonic plates* to which they were attached moved as spreading continued along the Mid-Atlantic Ridge. *What is the evidence that the movement of the two plates was not strictly in an east-west direction?*

7. Using a tracing paper and figure 3, determine the relative positions between the South America and west Africa coastline 50 million years ago.

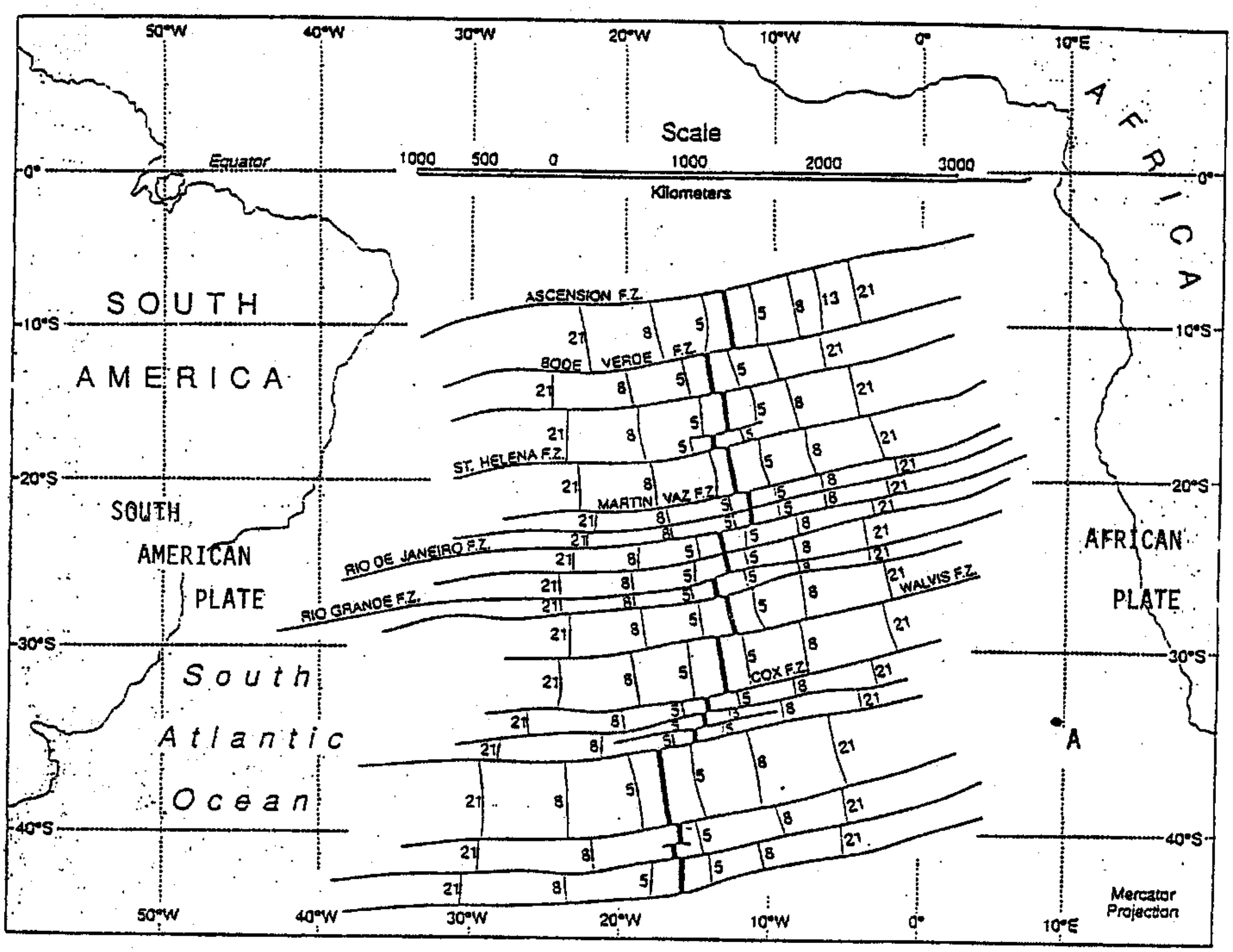


Figure 3. Map of the South Atlantic Ocean showing part of the Mid-Atlantic Ridge in black bars, the east-west fracture zones, and selected magnetic anomalies.

Part 2

The magnetic anomaly pattern in figure 4 was recorded in an ocean basin on a ship traverse across a mid-ocean ridge. The traverse is 800 km long.

1. At what distance does the traverse cross the mid-ocean ridge? Explain.

2. Using the expanded magnetic time scale of figure 5, find magnetic anomaly 2A. Examine the shape of anomaly 2A; identify this shape on the traverse of figure 4; determine distance of anomaly 2A from the ridge on figure 4.

3. Calculate the spreading rate for the plates on figure 4.

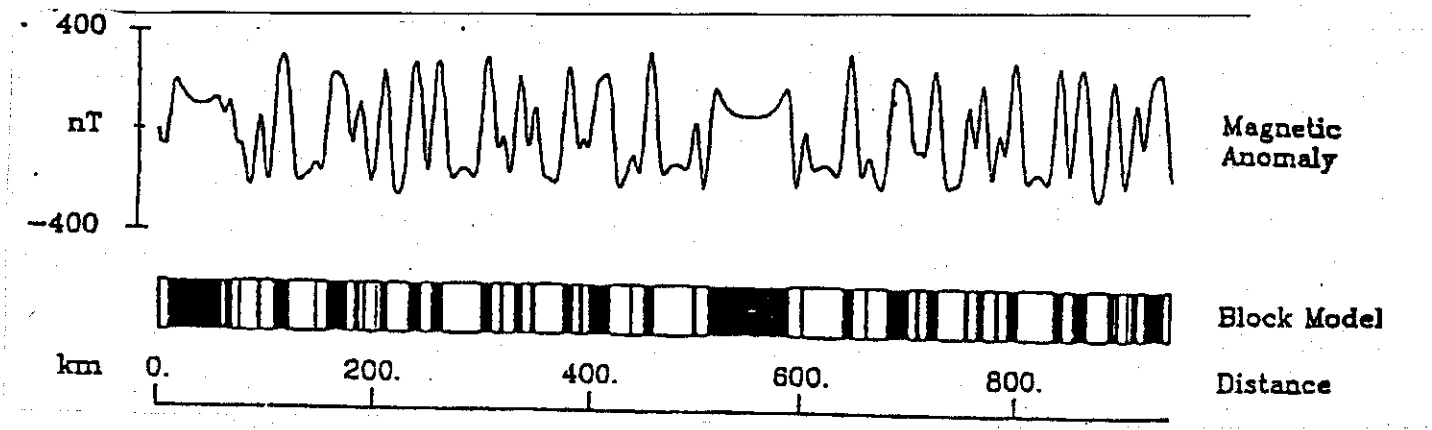


Figure 4.

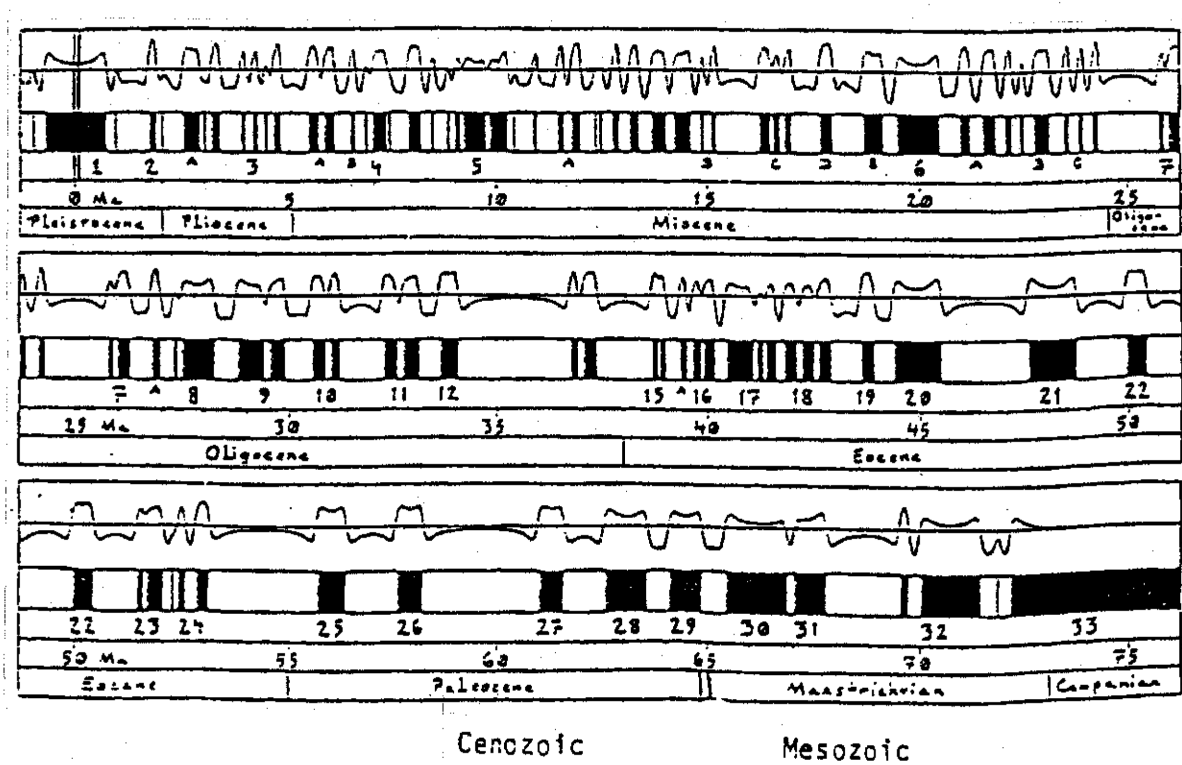


Figure 5.