THE DISTANCE BETWEEN US AND THEM: SEA FLOOR SPREADING IN THE ATLANTIC OCEAN

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Level: Grades 6 and above

Estimated Time Required: 50 - 65 minutes

Anticipated Learning Outcomes

- Students will gain an understanding of how geologists determine rates of sea floor spreading between two tectonic plates.
- Students will gain experience applying some basic, useful mathematical concepts such as the calculation and use of velocities and conversion from one set of units to another.

Background

Sea floor spreading is one component of the theory of plate tectonics. According to this concept, at ridges in many of the world's oceans (mid-ocean ridges), new crustal rock is added to the edges of plates on either side of the mid-ocean ridge. The mid-ocean ridge in the middle of the Atlantic Ocean is known as the Mid-Atlantic Ridge (MAR). At the MAR, new sea floor rock (basalt) is added to the edges of the North American, South American, Eurasian, and African plates. The result of the addition of new sea floor rock is that the Atlantic Ocean between these sets of continents is widening. North and South America move farther away from Eurasia and Africa each year.

The youngest sea floor rocks are found in the middle of the ocean because that is where new sea floor is added. As you move away from the MAR, the sea floor rocks become increasingly older. The oldest sea floor (the first Atlantic sea floor formed that is still preserved) is found closest to the continents. One way that geologists can recognize the strips of sea floor basalt created at, and subsequently moved away from, the MAR is by collecting and determining the magnetic properties and ages of rocks from the ocean floor.

Materials: (per student)

- Ruler with mm subdivisions or 1/10 inch subdivisions (C-Thru rulers work best)
- Calculator
- Copies of map, worksheets, and geologic time scale (provided in activity)
Procedures

A strip of map of a portion of the North Atlantic region is provided. The thin line that approximately parallels the easily-recognized coastline is the continental shelf edge. The continental shelf edge best defines the true edge of the sections of continental crust which at some time in the past were joined together to form a much larger continent known as Pangea (Pan-GEE-uh).

The bold line labelled "0" and located about half way between North America and Africa is the Mid-Atlantic Ridge (MAR), where new sea floor forms. On either side of the MAR are strips of sea floor basalt labelled with their ages in millions of years. For example, 55 million years ago, the strips of sea floor labelled "55" were formed at the MAR. Over the past 55 million years, these strips of rock have cooled and been moved away from the ridge where they were formed.

The distance between Point A on the North American continental shelf edge and Point B on the African continental shelf edge is approximately 4,550 kilometers (km). By following the steps outlined below, students will determine how much the distance between North America and Africa increases each year and how long ago the Atlantic Ocean began to open.

Students will need to determine a map scale using the given distance between Point A and Point B (4550 km), and the distance they measure between these points on their copy of the map. The spreading rates that students calculate in step #5 will vary between 18 and 24 km per My (1.8 to 2.4 cm per year) depending on which strip of sea floor basalt is used and how carefully measurements are made. (Calculations made using highly sophisticated means show that the present spreading rate in the Atlantic is about 2 cm per year.) Measurements between sea floor strips and the MAR should be made as close to perpendicular to the MAR as possible. This is the approximate direction of movement of sea floor basalt away from the ridge where it formed.

Sea floor spreading rates have not been constant through geologic time. Students will have calculated an average spreading rate over some period of time. Because the oldest sea floor shown on the map is 156 million years old, it is best to calculate an average spreading rate over some time period longer than about 50 million years. The relatively slow spreading rates calculated from sea floor rock aged 20 or 35 My will yield dates for the opening of the Atlantic which are older than they should be.

Because students will have calculated different spreading rates, the calculated times of opening of the North Atlantic Ocean will vary as well. In general, these dates should cluster around 190 to 220 million years ago, around the time of the Late Triassic and Early Jurassic periods. Certain geologic features in eastern North America are related to the initial "pulling apart" of the continent of Pangea. These include: 1) the Triassic Basins of Gettysburg, PA, and Richmond and Danville, VA, 2) the Palisades of NJ and NY, and 3) the Connecticut Valley of CT and MA. Students who fully grasp the concept of sea floor spreading will deduce that if sea floor is created at mid-ocean ridges, it must be destroyed elsewhere, or the Earth would be expanding. It is therefore helpful to have some understanding of subduction zones.

If students have a general understanding of how oceans affect continental climates (supplying
moisture, moderating seasonal temperature changes, occurrences of hurricanes, etc.), discuss how the climate of eastern North America might have been different 200 million years ago. You may wish to use the next exercise in this book, "Plate Movements and Climate Change".

References

Many recent world atlases and introductory geology and earth science textbooks contain discussions of the theory of plate tectonics and provide good illustrations for use in explaining sea floor spreading. For example, see:


NATIONAL GEOGRAPHIC ATLAS OF THE WORLD: 1990, National Geographic Society, Washington, D.C.
SEA FLOOR SPREADING RESEARCH GROUP
DATA WORKSHEET

Date__________

Investigators___________________________________________________

1. Study area: **North Atlantic Ocean**

Select one strip of sea floor rock. Record its age below and carefully measure the distance it has moved from the mid-ocean ridge where it formed.

2. Sea floor age: ______________million years (My)

3. Distance to the Mid-Atlantic Ridge

   (distance measured on map X map scale): ________________kilometers (km)

Using the age of the rock you have chosen and its distance from the MAR, calculate the half-rate of sea floor spreading, the velocity at which one strip of this rock has spread away from the MAR.

4. Calculated half-rate (velocity) of sea floor spreading

   (distance / time = velocity in cm/year): ________________km per My

5. Calculated total rate (velocity) of sea floor spreading

   (2 x half-rate = total spreading rate): ________________km per My

6. Total present day distance between North America and Africa

   (measured between points A and B): 4550 km

7. Calculated age of the North Atlantic Ocean

   (total distance / total velocity = time) : ________________My
8. Geologic Period during which the North Atlantic began to open:

9. Convert the total sea floor spreading rate from step #5 above to units that are easier to "imagine". This can be done simply by filling in the spaces below and performing the multiplication. Check this calculation by making sure that units "cancel out" to correctly yield the units desired (this procedure is known as dimensional analysis).

\[
(____\text{km/My}) \times (____\text{mi/km}) \times (____\text{ft/mi}) \times (____\text{in/ft}) \times (____\text{My/yr}) = _____\text{in/yr}
\]

How much has the distance (in inches) between North America and Africa increased since you were born?

How much does the distance (in feet) increase during the average lifetime of an American (~82 years)?

How much closer (in feet) were these two continents when Columbus made his voyages?
Strip map of a portion of the North Atlantic region showing the coastlines and continental shelf edges of North America and Africa. The bold line labelled "0" is the Mid-Atlantic Ridge. Selected strips of sea floor basalt on either side of the ridge are labelled with their ages in millions of years. The approximate distance between Point A and Point B is 4,550 kilometers.
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