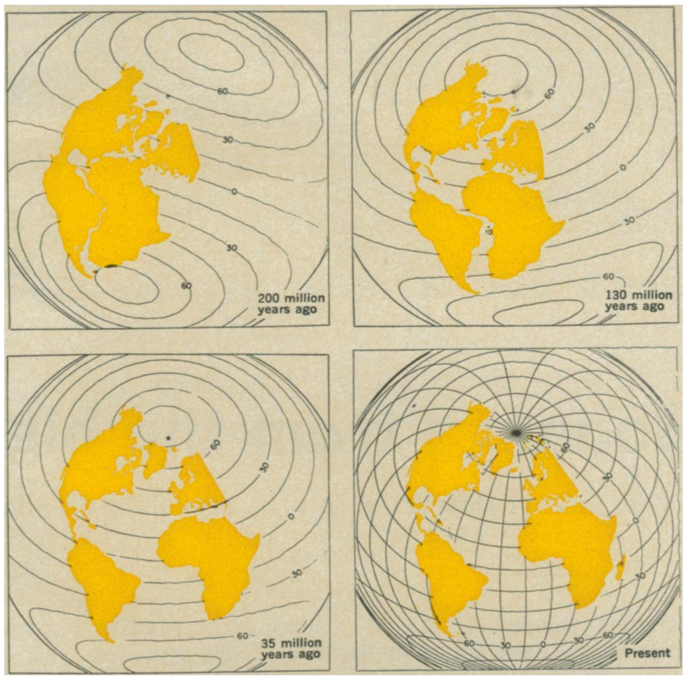
The Atlantic's grand opening

New evidence permits more and more detailed models of the formation of the Atlantic Ocean



Phillips and Forsyth/GSA Bulletin

Four proposed stages in the opening of the Atlantic.

by Louise A. Purrett

Three years ago Sir Edward Bullard of the University of Cambridge wrote that scientists had a sketch of the outlines of a history of the oceans; what remained was a mass of detail. There is still much to be learned about the formation of the oceans, but new evidence on crustal ages, location of ocean floor fractures, and magnetic anomaly patterns has been accumulating rapidly and is being interpreted in terms of the theory of plate tectonics

In the June GEOLOGICAL SOCIETY OF AMERICA BULLETIN Joseph D. Phillips and Donald Forsyth of Woods Hole Oceanographic Institution propose a detailed history of the Atlantic Ocean. Bullard and his colleagues have described the motions of the continents in terms of rotations about a pole. The Woods Hole geophysicists combined data on the age of the ocean floor at different locations with finite rotations of the continents around Bullard's poles.

The classic predrift arrangement of the continents proposed by Bullard, in which the east coast of South America fits against the west coast of Africa, and Greenland fills the gap between Europe and North America, has not been successfully challenged.

The birth of the Atlantic began 200 million years ago, with rifting in two places. Northwestern Africa separated from North America, and the Rockall Trough, a narrow basin between Britain and Iceland, began to open. Volcanic rocks between 190 million and 202 million years old in the eastern United States are believed to be associated with the initial rifting. For the first 70 million years, sea-floor spreading in the central Atlantic proceeded at a rate of about 1.7 centimeters per year. Between 130 million and 65 million years ago, the spreading rate in the central Atlantic decreased to about 1.4 centimeters per year, and has slowed down even more since then, to about 1.2 centimeters per year.

Because the Rockall Trough was not complete until 130 million years ago, the spreading rate there must have been extremely slow, even by continental drift standards: about 0.1 centimeter per year. Next the Labrador Sea between Greenland and North America began opening, probably about 80 million years ago. Then things really got complicated. Before the Labrador Sea had opened completely, spreading began in two other places about 65 million years ago: the Reykjanes Ridge between Iceland and the Gibbs Fracture Zone and along the Mid-Atlantic Ridge north of the Azores. Spreading in the Labrador Sea was completed by 45 million years ago, but for 20 million years spreading was occurring in three different locations in the north Atlantic.

The opening of the South Atlantic was much simpler, and consisted of rifting between South America and Africa beginning sometime after 150 million years ago. Spreading along this southern section of the Mid-Atlantic Ridge is known to have been steady at 2.0 centimeters per year for at least the last 70 million years. A 125-million-year-old volcanic formation in South America may be associated with the initial rifting, the researchers believe. If so, a constant rate of 2.0 centimeters per year would just about account for the present width of the ocean.

Over the course of the 200-million-year period, the entire Atlantic plate system has gradually shifted northward.

The interactions between the continents bounding the Atlantic allow some inferences about the histories of adjoining smaller bodies of water. Because the north and south Atlantic opened at different times along the same ridge, there must have been a fault or spreading ridge between North and South America to take up the differential motion. The researchers estimate that the Caribbean Sea would have opened as a consequence of separation between the Americas. The ancient Tethys Sea between Africa and Europe was closed by the convergence of these two continents; what remains is the Mediterranean.

When molten rock solidifies it absorbs the prevailing magnetism of the earth's field. The magnetism preserved in rocks formed at the same time should therefore point toward the same spot—the location of the earth's magnetic pole at the time of solidification—unless the rocks have subsequently been moved. Phillips and Forsyth checked their proposed model by calculating the continental positions and movements that would account for observed magnetism of rocks from the different continents.

They report the proposed reconstruction agrees quite well with paleomagnetic data, with a few exceptions. For example, Carboniferous (345 million to 280 million years ago) data for South America and Permian (280 million to 230 million years ago) data for Africa do not fit the proposed model. To try to resolve these discrepancies, they tested a slightly different model, in which Greenland was rotated more than in the other. The alternate model, in general, fits the magnetic data better, they conclude, but the improvement is not great enough to justify rejecting the original model. □