Some plate-tectonic thoughts on the early opening of the South Atlantic Ocean

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Plate tectonics starts with the realization that the earth's lithosphere today is divided into a small number of large plates with seismicity mostly confined to their common margins. Uniformitarianism, the foundation of geology, says that things were always like this. But active plate boundaries change position over time and even minor intra-plate exceptions (e.g. the North Sea graben) are not negligible from an economic standpoint.

As a result of many years of work in Africa and elsewhere, the former (super-) continent of Gondwana has been divided into about 50 lithospheric fragments that have each individually remained rigid since Gondwana became a single, stable continent with the ending of collisional tectonics very early in the Phanerozoic. Over much of Gondwana, this stability persisted for 350 million years. Relative movements between these constituent Precambrian pieces since Gondwana started disruption about 180 Ma provide a measure of crustal extension, not only at the passive margins of the continents that were formed but at internal rifts within Africa, for example.

The record of Gondwana dispersal is in the sea floor topography and the magnetic anomalies ('stripes') that help constrain the timing of continental movements. Good, worldwide data on the former have only been available for the last 15 years. Carefully retracing the process of ocean growth with time leads to a model of the dispersal process and puts limits on the original relative configuration of the constituent fragments in a rigid, stable Gondwana. Within the South Atlantic Ocean, the earliest phases of rifting between what is now Africa and South America, the transition of rifting in to drifting and eventually to passive margin development are the most important to understanding the petroleum potential along the formerly conjugate coasts.

A reliable starting point for pre-drift rifting would eliminate some important sources of uncertainty in these earlier phases of ocean development. An important unknown is the width of the strip of Precambrian crust that has been lost from outcrop through extension and subsidence during the pre-drift rifting process. An accurate 'fit' depends on reliable detail in the present-day outcropping geology having large, mappable features such as major vertical faults that may be correlated reliably from one continent to the other, across the missing strip.

In the process of modeling, the opening of the South Atlantic Ocean has been reduced to its barest essentials, consistent with the latest available fracture zone data, in an attempt to understand better the precise original fit of South America and Africa and the Euler geometry of the earliest phases of rifting. The first scissor-like wedging apart of the two continents, presumably under the influence of the Tristan mantle plume, must have changed into a more coast-normal relative movement once the full length of mid-ocean ridge was established and the Equatorial Atlantic propagated westward towards the Central Atlantic. This would amount to a change in spreading direction of about 30 degrees at about 125 Ma (early Aptian) in the southernmost part of the ocean.

A prototype animation of the whole process based on the 2010 Geological Map of the World is to be found at http://www.reeves.nl/upload/SouthAtlantic1.gif