The first fracture

The movement of Gondwana nearly resulted in Brazil's northeastern region becoming a part of Africa

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PUBLISHED IN FEBRUARY 2012

A significant part of what is now Brazil's northeastern region nearly became part of Africa during the movement of the great rock masses that make up the continents, the so-called continental drift. The hypothesis that Brazil's northeast could have split off first arose in the 1960s and has recently gained support as a result of evidence obtained by researchers from the Federal University of Rio Grande do Norte (UFRN) and from the University of Brasília (UnB).

According to this scenario, which went as far as being geologically initiated but was interrupted for reasons not yet completely understood, South America would have had a much smaller land mass, whereas Africa would have been more triangle-shaped, rather than having its current upside-down "L" shape. "Salvador's Carnival would have to be celebrated on the other side of the ocean," explains David Lopes de Castro, a geophysicist at UFRN and one of the study's four authors.

This paper, published in the *Journal of Geodynamics*, outlines the evolution of the so-called Potiguar Basin, a formation on the coast of the States of Ceará and Rio Grande do Norte that was the last part of South America to break off from Africa.

As is well known, the continents are engaged in a constant dance over the course of the geological timescale, one minute moving closer together and the next moving away from each other, due the dynamics of the tectonic plates. These rigid plates, which are up to 100 kilometers thick, slowly slide, carrying with them whatever is above them, as if they were huge ferries navigating over the Earth's paste-like interior.

Approximately half a billion years ago, Africa, South America, Australia, the Arabian Peninsula, India and the Antarctic were all joined together in a super-continent that geologists call Gondwana.

"In what is now the northwestern region of Africa and the northeastern region of Brazil, there was a mountain range not very different to the Andes," explains Francisco Hilário Bezerra, another of the study's authors and also from UFRN.

The region was unstable, which is to be expected from a piece of land that was on the verge of splitting in two. The final separation between South America and Africa occurred approximately 100 million years ago. The split gave rise to the Potiguar Basin on the South American side and to the Benue Basin on the African side. Between the two arose the Atlantic Ocean.

DECODING THE DIVISION

What the Brazilian researchers proposed was to search for the pieces of the jigsaw puzzle on the two sides of the ocean, mainly to describe the geological characteristics on each side.

The researchers worked with gravimetric and magnetometric data. Despite their complicated names, these measurement techniques are based on simple concepts. The first relates to the variations in the Earth's gravitational field, and the second relates to its magnetic field.

It may seem strange, but the Earth's mass – which is responsible for its gravitational field – is not equally distributed around the globe. Because of this irregularity, there are regional fluctuations in the gravitational field. By analyzing these fluctuations, geophysicists are able to calculate what lies beneath the soil.

The red line marks the area where the start of the separation between Africa and South America probably began and that generated the fractures, on top of which lie the Potiguar, Jatobá and Tucano-Recôncavo basins in the Brazilian Northeast. (above)

SOURCE CASTRO, D. L. *ET AL.* **IMAGES 1.** NASA / CORBIS / GLOWIMAGES **2.** MARIA SOUSA / UFRN

The same is true of the magnetic field. The strength of the magnetic field depends on the composition of the underground rocks. "It depends on the intensity of magnetization of each rock," explains David Castro.

"The sedimentary rocks that make up the Potiguar Basin have a low-intensity magnetic field, and this creates the contrast with the foundation rocks," he says.

Most of the raw data were not collected by the scientists themselves. On the Brazilian side, much of the information came from previous surveys performed by Petrobras. These data were passed on to the researchers by the National Petroleum Agency (ANP). On the African side, the information came from freely accessible international databases. The group did have to collect some gravimetric data. The effort entailed transporting a gravimeter (a device just slightly larger than a conventional computer) along the freeways of the states of Rio Grande do Norte and Ceará, taking measurements at numerous points along the way. "We would put it on the ground, take our measurement and then resume our journey," explains Castro.

Much of the data provided by the ANP were collected by means of aerial surveys during flights over the areas in question. These measurements help scientists estimate the region's magnetic field. However, the researchers opted not to use gravimetric data collected by satellites in the continental regions. Although such data offer much broader coverage of the entire globe, their resolution is not sufficient to provide the level of precision that the researchers needed to produce a detailed breakdown of the Potiguar Basin and its adjacent areas.

The researchers took one measurement per kilometer on average (some of the data obtained from the ANP had an even closer spacing of 500 meters). Putting all this information together, they were able to estimate the configuration of that area's subsoil. Using gravimetry, it was possible to identify the characteristics of rocks to a

depth of up to 50 kilometers. In the case of magnetometry, the range is smaller, but still impressive: roughly 20 kilometers.

The data from the two techniques were then combined to produce a survey of the region – sometimes going as far as to map the rock up to the interface between the Earth's crust and the layer immediately below, the mantle. As a result, the researchers were able to identify the precise alignment of the Potiguar Basin with two other basins that are adjacent and further to the south: the Jatobá Basin and the Tucano-Recôncavo Basin. Together, the borders of these basins draw a line that runs from north to south and stretches from the boundary between the states of Ceará and Rio Grande do Norte to the northeast of the State of Bahia.

DEEP FRACTURE

Based on a precise analysis of the Potiguar data, the researchers were able to identify the alignment of a very deep fracture that is believed to be the clearest indication that Gondwana originally began to break apart in that region rather than further east, as it did millions of years later.

The question that remains unanswered, in light of this surprising evidence of a near continental split, is: why did the break fail to materialize? Nobody has a definite answer, but the speculation is that this region may be more resistant to ruptures than the region where the split actually occurred, hundreds of kilometers to the east. A number of geologists have suggested that the tension that began further inland in the South American continent may have been transferred to other fault lines, causing the split to occur somewhere else. To date, however, there is no conclusive evidence explaining why the rupture along the border of the Potiguar Basin was interrupted. This lack of evidence is a good reason to continue the research.

The work of the Brazilian group, which included the geologist Reinhardt Fuck, from UnB, went into greater depth with a line of research that was first explored in the mid-1990s by the researcher Roland Raymond Trompette, who was then a professor at the University of São Paulo and who now works at the French National Center for Scientific Research. The Brazilian study validated the results obtained by the French researcher and furnished more details about the region's geology, in addition to showing how the pieces of the jigsaw puzzle, which ended up on different sides of the Atlantic Ocean, fit together.

A deep fracture suggests that Gondwana began to separate farther west

When two continents separate, the division is not very different from the divisions created by humankind with their frontiers. Just as the Berlin Wall divided families and even houses in the German capital after World War II, the separation between South America and Africa divided sister regions, created by geological formations that began on one side of the Atlantic Ocean and ended on the other.

Thus, it came as no surprise that the new mapping revealed geological fault lines with a linear continuity from America to Africa. What is intriguing is that, after 130 million years, things have hardly changed, although an ocean has appeared between the two continents.

The Potiguar Basin is of special interest, not merely out of scientific curiosity, but for its economic potential because it contains considerable oil reserves, hence the collection of abundant data by Petrobras. "The basin is what is conventionally called a mature petroleum field, and the major petroleum reserves have already been discovered," says Castro.

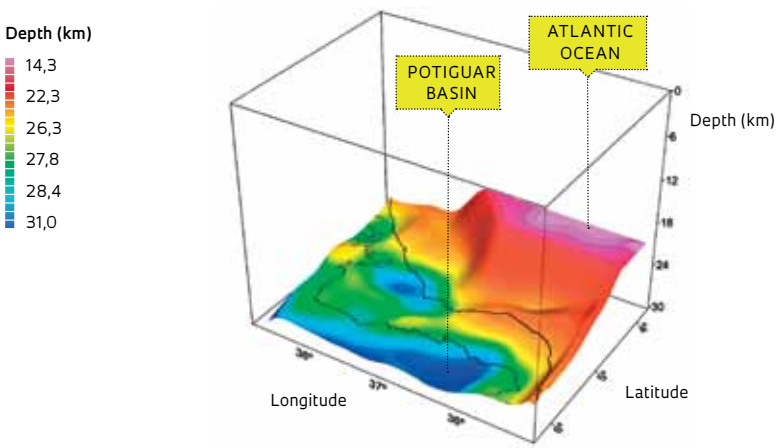
According to Castro, the results of this study could help in future prospecting, not just in South America but also in Africa. "Based on the results, one might look for the same geological situations in Africa. They say that they also have pre-salt reserves there, like we have here."

One contribution of the study results is that they foster basic research. In other words, everything starts with scientific exploration, which leads to economic exploitation, which now, thanks to the data collected, leads back to science. And so the cycle continues.

"What we are looking for are the small details, to try to understand the region's evolutionary history," he explains. "Overall, it's also important to continue to look for more oil, as this leads to a better understanding of the mechanisms that generate it and cause it to accumulate." ■

Geological scar

The depth of the sedimentary basin under the States of Rio Grande do Norte and Ceará varies from 22 to 31 kilometers



Scientific article

CASTRO, D.L. *et al.* Influence of Neoproterozoic tectonic fabric on the origin of the Potiguar Basin, northeastern Brazil and its links with West Africa based on gravity and magnetic data. **Journal of Geodynamics.** v. 54, p. 29-42. Mar. 2012.

SOURCE CASTRO, D. L. *ET AL.*