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Tectonic and Paleobathymetric evolution of the South Atlantic Basin

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It is no surprise that the opening of the South Atlantic ocean is one of the most extensively researched problems in plate kinematics. After all, it was the similarity of the coastlines of South America and Africa that inspired the basic foundations of plate tectonic theory. An accurate representation of the plate motions that led to the growth of this ocean basin is crucial to understanding the dynamics of its margins, the formation of petroleum systems and the driving mechanisms behind present and past water circulation patterns. General agreement exists about ocean opening being the result of the diachronous separation of two major plates (South American and African), having involved a certain degree of intracontinental deformation. However, for a fuller understanding, the bathymetric evolution also needs to be considered.

Here, we present a series of high resolution paleobathymetric reconstructions (Early Cretaceous to present) for the South Atlantic which represent a big step forward with respect to previous attempts, for three reasons. First, the foundation of our modelling procedure is a robust plate tectonic model based on high-resolution seafloor spreading data. Second, our workflow accounts for a number of processes affecting bathymetry at a variety of temporal and spatial scales (both within the ocean and the extended continental margins), neglected by other paleobathymetries published to date. Lastly, we have thoroughly quantified the uncertainties in our modeling approach, which allows us to provide accuracy estimates for our reconstructions.

Our modelling procedure follows a number of steps. First, we calculate an "idealised" basement surface by applying plate-cooling theory to seafloor ages and integrating the results with COTZ depths as predicted by removing the effects of post-breakup processes on their present-day bathymetry. Then, we refine the depths of this basement surface to account for the effects of sedimentation, variations in crustal thickness and mantle fluctuations.

Most of the paleodepths modelled following our approach are accurate to <1 km, offering a strong quantitative basis for studies of paleocirculation, paleoclimate and paleobiogeography. Circulation in an initially salty and anoxic ocean, restricted by the topography of the Falkland Plateau, Rio Grande Ridge and Walvis Rise, favoured deposition of thick evaporites in shallow water of the Brazilian-Angolan margins. This ceased as seafloor spreading propagated northwards, opening an equatorial gateway to shallow and intermediate circulation. This gateway, together with subsiding volcano-tectonic barriers would have played a key role in Late Cretaceous climate changes. Later deepening and widening of the South Atlantic, together with gateway opening at Drake Passage would lead, by mid-Miocene (∼15 Ma) to the establishment of modern-style thermohaline circulation.