Constraining South Atlantic Growth With Seafloor Spreading Data

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1. INTRODUCTION AND RATIONALE

The opening of the South Atlantic Ocean is one of the most extensively researched problems in plate kinematics. Models of it have proliferated since Bullard, Everett and Smith [8] published the first-ever computer-assisted reconstruction in the 60s. In recent years, focus has shifted to understanding the early stages of continental separation. General agreement exists about ocean opening being the result of the northward propagating mid-Atlantic ridge between two main tectonic plates, implying a certain degree of intracontinental deformation. Modern studies assign most of this intracontinental deformation to narrow mobile belts between large plate-like continental blocks in order to achieve best fits of the blocks' extended continental margins [1-6].
The geological record of intracontinental deformation constrains the magnitude, orientation, and timing of block motion at very low resolution only. Similarly, with continent-ocean transition zones in the South Atlantic being up to 150 km wide, the ages and shapes of the extended margins are not unanimously interpretable at high resolution. Therefore, these are not suitable basis on which to lead a reconstruction effort. Aiming to avoid the uncertainties inherent in this approach, plate divergence has been modelled as depicted by seafloor spreading data (fracture zone traces and magnetic anomaly identifications), and this model has then been used as a context within which to interpret intracontinental tectonic motions [9].

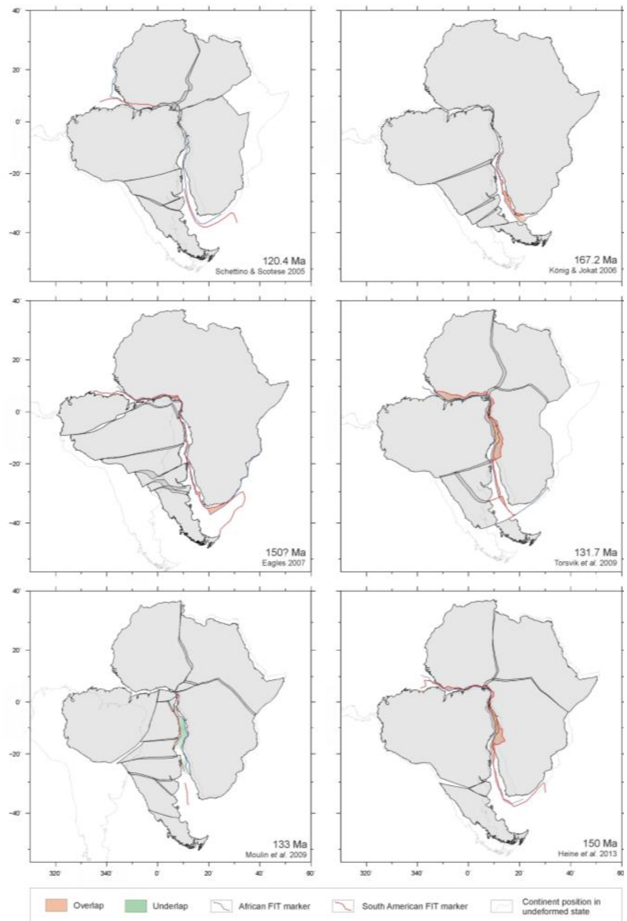

Fig. 1: Simplified view of some recent South Atlantic reconstructions showing the variety of interpretations of intracontinental accommodation zones and continent-ocean boundaries [1-6]. Fixed block: Northwestern Africa

2. SUMMARY OF MAIN RESULTS

(Please see Supplementary Figure 1 and animated tectonic reconstruction contained in CD)
The opening of the South Atlantic can be neatly explained in terms of the divergence of only two plates starting in Valanginian times. Seafloor spreading starts at 138 Ma (Fig. 2). Motions along four South American accommodation zones lead to its assembly by 123 Ma. Seafloor spreading is accommodated by motions along the Colorado Basin and Macachin Trough (138-134 Ma) and

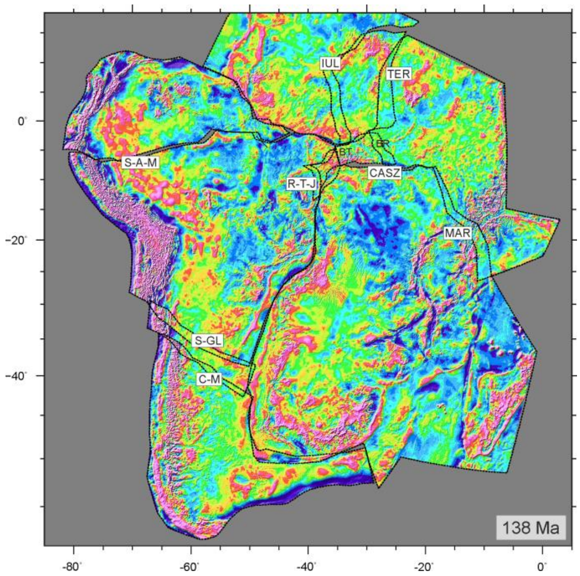

Fig. 2: Initial continental block configuration prior to seafloor spreading over satellite-derived free-air gravity anomaly data from Sandwell and Smith [7]. BT: Benue trough; BR: Bongor Rift; CASZ: Central African Shear Zone; C-M: Colorado basin, Macachín trough; IUL: Iullemeden rift; MAR: Muglad-Anza Rift; R-T-J: Recóncavo-Tucano-Jatobá basins; S-A-M: Solimões-Amazon-Marajó basins; S-GL: Salado and General Levalle basins; TER: Termit basin.

Salado-General Levalle basins (134-126 Ma). These timings are supported by the broadly constrained published ages for the basins' sedimentary infills [10-12]. Between 126 and 123 Ma, western displacement of the assembled southern blocks of South America results in deformation along the Recôncavo-Tucano-Jatobá basins and Solimões-Amazon-Marajó accommodation zone [13-16]. The assembly of Africa is depicted to have taken place between 123 and 106 Ma. Deformation along the Central African Shear Zone, the Termit basin and Benue Trough first, and then the Iullemeden rift in northwest Africa leads to continental assembly by 106 Ma [17-21]. Shallow and intermediate-depth water exchange is believed to have started at around 100 Ma.

This new kinematic model presents a plausible history for the opening of the South Atlantic, putting features such as the Vema Channel, the Malvinas plate and the Southern Ocean Large Igneous Province in context by offering explanations for their formation and evolution.

Besides, it challenges the view of narrow deformation belts within the surrounding continental interiors as the sole sites of stress accommodation. When the motions depicted by the model are compared to published estimates of basin extension it is found that such features may only account for around 60% of the total strain implied by the growth of the South Atlantic. Northward mid-ocean ridge propagation is likely to have been accommodated by a variety of mechanisms acting at all scales (both temporal and spatial) and at sites spread throughout the continental interiors, approximating distributed deformation.

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