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Paleogeographic evolution of the central segment of the South Atlantic during Early Cretaceous times: Paleotopographic and geodynamic implications

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ABSTRACT

The geodynamic processes that control the opening of the central segment of the South Atlantic Ocean (between the Walvis Ridge and the Ascension FZ) are debated. In this paper, we discuss the timing of the sedimentary and tectonic evolution of the Early Cretaceous rift by drawing eight paleogeographic and geodynamic maps from the Berriasian to the Middle–Late Aptian, based on a biostratigraphic (ostracodes and pollen) chart recalibrated on absolute ages (chemostratigraphy, interstratified volcanics, Re–Os dating of the organic matter).

The central segment of the South Atlantic is composed of two domains, with a two phases evolution of the pre-drift ("rifting") times: a rift phase characterized by tilted blocks and growth strata, followed by a sag basin. The southern domain includes the Namibe, Santos and Campos Basins. The northern domain extends from the Espirito Santo and North Kwanza Basins, in the south, to the Sergipe–Alagoas and North Gabon Basins to the north.

Extension started in the northern domain during the Late Berriasian (Congo–Camamu Basin to the Sergipe–Alagoas–North Gabon Basins) and migrated southward. At that time, the southern domain was not a subsiding domain (emplacement of the Parana–Etendeka Trapp). Extension started in this southern domain during the Early Barremian. The rift phase is shorter in the south (5–6 Ma, Barremian to base Aptian) than in the north (19 to 20 Myr, Upper Berriasian to base Aptian). The sag phase is of Middle to Late Aptian age. In the northern domain, this transition corresponds to a hiatus of Early to Middle Aptian age.

From the Late Berriasian to base Aptian, the northern domain evolves from a deep lake with lateral highs to a shallower organic-rich one with no more highs. The lake migrates southward in two steps, until the Valanginian at the border between the northern and southern domains, until the Early Barremian, north of Walvis Ridge.

1. Introduction

The South Atlantic Ocean results from the breakup of Gondwana into two continents, South America and Africa, during Early Cretaceous times. It can be divided into four segments (Moulin et al., 2005): the Falkland segment, south of the Agulhas–Falkland Fracture Zone (AFFZ), the southern segment from the AFFZ to the Rio-Grande FZ, the central segment from the Rio-Grande to the Ascension FZ, and the equatorial segment from the Ascension to the Marathon FZ (Fig. 1).

On both South American and African sides, the central segment is characterized by a sag basin phase (Karner and Driscoll, 1999; Karner et al., 2003; Lentini et al., 2010; Marton et al., 2000), prior to salt deposition and oceanic accretion, and after a rift phase characterized by blocks tilting in the upper continental crust. The sag basin (also called pre-salt sag basin or pre-salt wedge) is characterized by a thick wedge of sediments (3 to 5 km), with no evidence of brittle extension (tilted blocks with syn-sedimentary normal faults with a wavelength of several kilometers to several tens of kilometers). It looks like a large wavelength (several hundreds of kilometers) "flexural" basin. In its proximal part, this sag basin onlaps the tilted blocks mentioned above (Moulin et al., 2005).

This two steps evolution, with a rift phase with tilted blocks and growth strata first and a sag phase second, does not fit with classical

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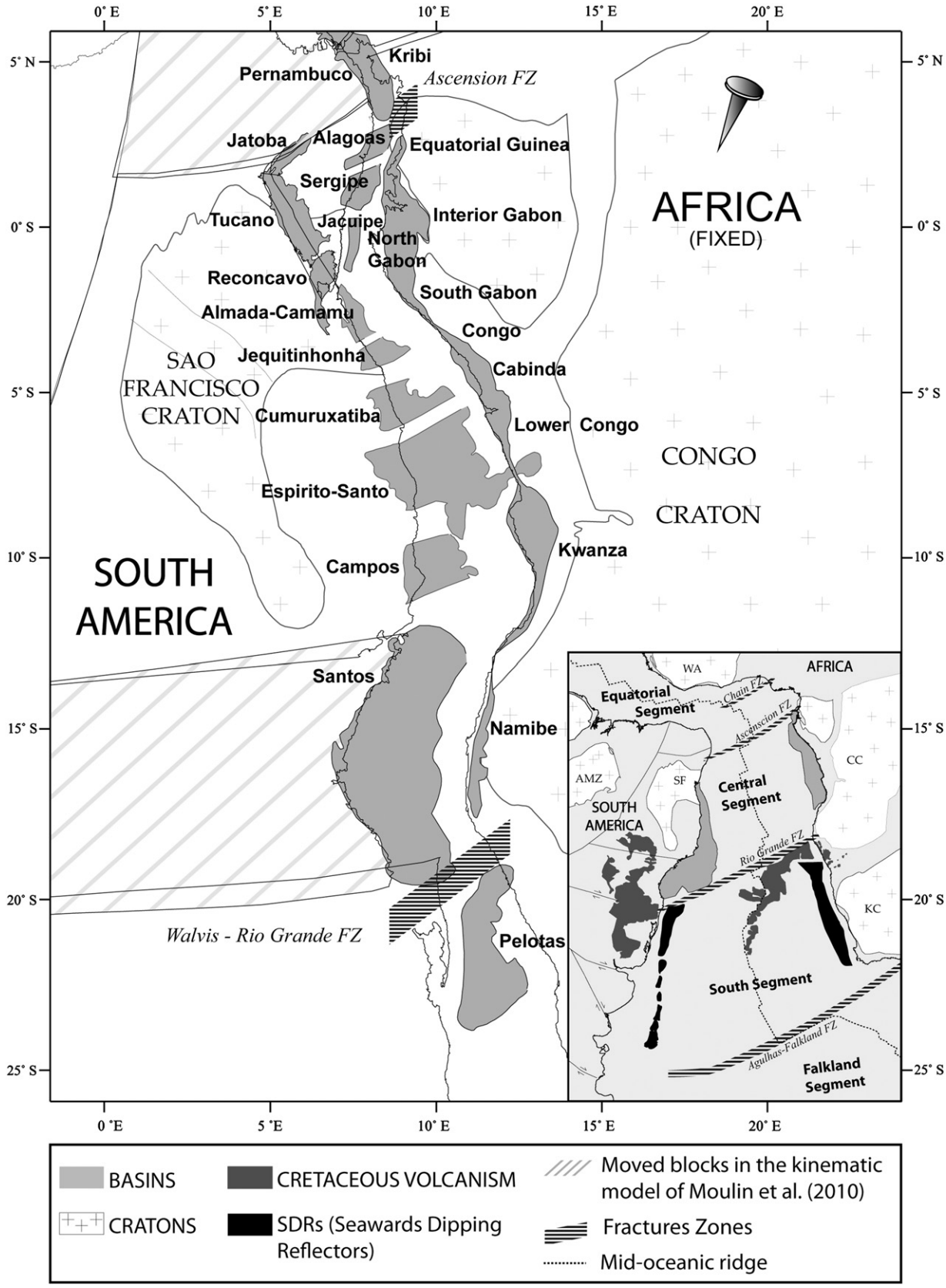

Fig. 1. Location map of the studied basins at their original position during Berriasian times (plate kinematic model of Moulin et al., 2010), and general map of the different segments of the South Atlantic Ocean (modified from Moulin et al., 2010).

models of uniform lithospheric extension, pure shear (McKenzie, 1978) and simple shear (Wernicke, 1985) models. Thus, alternative depth dependent models were proposed. By applying the model of Lavier and Manatschal (2006), with brittle layers within the lower crust and the upper mantle, Unternehr et al. (2010) suggest a two phases conservational model (the volume of continental crust at the