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# Geochemical and isotopic composition of Pan-African metabasalts from southwestern Gondwana: Evidence of Cretaceous South Atlantic opening along a Neoproterozoic back-arc

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ABSTRACT

A lithogeochemical and Sr–Nd–Pb isotope study of former oceanic crustal rocks from the Cuchilla Dionisio Terrane in the southern Dom Feliciano Belt, Uruguay (La Tuna amphibolites) and metabasites in the Chameis Subterrane of the Marmora Terrane in the Gariep Belt, Namibia/South Africa shows that these rocks are compositionally very similar and probably represent the same unit on opposite sides of the modern South Atlantic. The mafic rocks from both terranes are tholeiitic metabasalts and -andesites and have depleted rare earth element patterns, generally low $TiO_2$ (<1.5 wt.%), very low Th/Nb ratios and lack negative Nb–Ta anomalies, all features that are typical of 'normal' mid-ocean ridge basalts (N-MORB) and/or back-arc basin basalts (BABB). In addition, both rock suites have extremely depleted Nd isotope compositions ($\varepsilon_{Nd}^{630\ Ma} = 6.7–9.4$), superchondritic $^{147}Sm/^{144}Nd$ ratios, and low $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ initial ratios. The $^{87}Sr/^{86}Sr$ initial ratios of the La Tuna mafic rocks are low, whereas the Chameis metagabbro samples have higher, possibly alteration-related ratios. The geochemical and isotopic signatures are consistent with the formation of both rock suites in the same mature Neoproterozoic back-arc basin (Marmora Basin), supporting conclusions drawn from earlier provenance studies of metasedimentary units from these terranes. Other mafic rocks from the Marmora Terrane are interpreted as ocean island basalts that formed in a within-plate setting.

A corollary of the conclusion that the mafic rocks in the Cuchilla Dionisio and Marmora Terranes formed in the same back-arc basin is (1) that the main Pan-African suture between the Río de la Plata Craton and the Kalahari Craton lies to the west of the Dom Feliciano Belt in South America, and (2) that the opening of the modern South Atlantic did not occur along that suture but along the axis of the Neoproterozoic Marmora back-arc basin.



## 1. Introduction

A strong influence of older, Precambrian structures on the location of South Atlantic opening during Gondwana break-up has been intuitively assumed by many workers for some considerable time (e.g., Clemson et al., 1997; Jourdan, 2006; Stanistreet and Charlesworth, 2001). Such an influence has been confirmed by a recent analysis of Pan-African and Early Cretaceous structures, with the latter being related to Gondwana break-up and the initiation of South Atlantic rifting in southwestern Africa (Will and Frimmel, 2013). The nature of the Precambrian basement structures, presumed to have influenced the site of Cretaceous rifting, has been a matter of debate. Traditionally, these structures have been related to the suture between the combined Congo and Kalahari cratons in the east and the Río de la Plata Craton in the west, following the orientation of the intervening Neoproterozoic Adamastor ocean (e.g., Frimmel et al., 1996a; Hartnady et al., 1985; Porada, 1979). In this model the orientation of the Gariep, Kaoko, western Saldania and Dom Feliciano orogenic belts (Fig. 1) would follow the long axis of the Adamastor ocean and, consequently, would be in the same position and orientation as the later South Atlantic rift. More recently, the application of a Wilson Cycle model to explain the various coast-parallel Pan-African tectonic belts along the South Atlantic margins has been challenged on the basis of new geochronological, petrological and stratigraphic data, especially zircon provenance data (Basei et al., 2005, 2008; Frimmel et al., 2011, 2013; Gaucher et al., 2008, 2009; Gray et al., 2006; Hoffmann et al., 2004; Misi et al., 2007). Instead, it seems more likely that the main suture was located to the west of the Dom Feliciano Belt within South America and the Kaoko, Gariep and western Saldania belts formed along a former back-arc basin (Basei et al., 2005, 2008; Bossi and Gaucher, 2004; Frimmel et al., 2011, 2013; Gaucher et al., 2009).

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Provenance analyses of detrital zircon grains from Pan-African orogens on both sides of the modern South Atlantic (Basei et al., 2005, 2008; Frimmel et al., 2013) show that metasedimentary units in the Cuchilla Dionisio Terrane (southern Dom Feliciano Belt, Uruguay), the Marmora Terrane (western Gariep Belt, Namibia) and the Malmesbury Terrane (western Saldania Belt, South Africa) have very similar detrital zircon grain age patterns with main peaks at around 1000 and 600 Ma. Basei et al. (2005, 2008) and Frimmel et al. (2013) argued that the source of the younger zircon grains is the 640–570 Ma calc-alkaline Aiguá-Pelotas magmatic arc in Uruguay and southern Brazil (Fig. 1), and that the main suture associated with the amalgamation of SW Gondwana, represented by the Sierra Ballena–Major Gercino Shear Zone, lies in South America. To test this hypothesis we followed a different but complementary approach by undertaking a lithogeochemical and Sr–Nd–Pb isotope study of oceanic crustal rocks from the Cuchilla Dionisio and Marmora Terranes. Preliminary data for the latter have been published previously (Frimmel et al., 1996a), and this data set was considerably extended in this study with new geochemical and isotope data. In contrast, no geochemical and isotope data exist for a suite of mafic and ultramafic rocks in the Cuchilla Dionisio Terrane, which have been suspected of being of oceanic origin (Bossi et al., 1998). Thus the main objective of this study is to evaluate whether the mafic and ultramafic rocks in the Cuchilla Dionisio Terrane of Uruguay and the Marmora Terrane in southwestern Namibia and South Africa are related to each other and to evaluate their original tectonomagmatic setting.

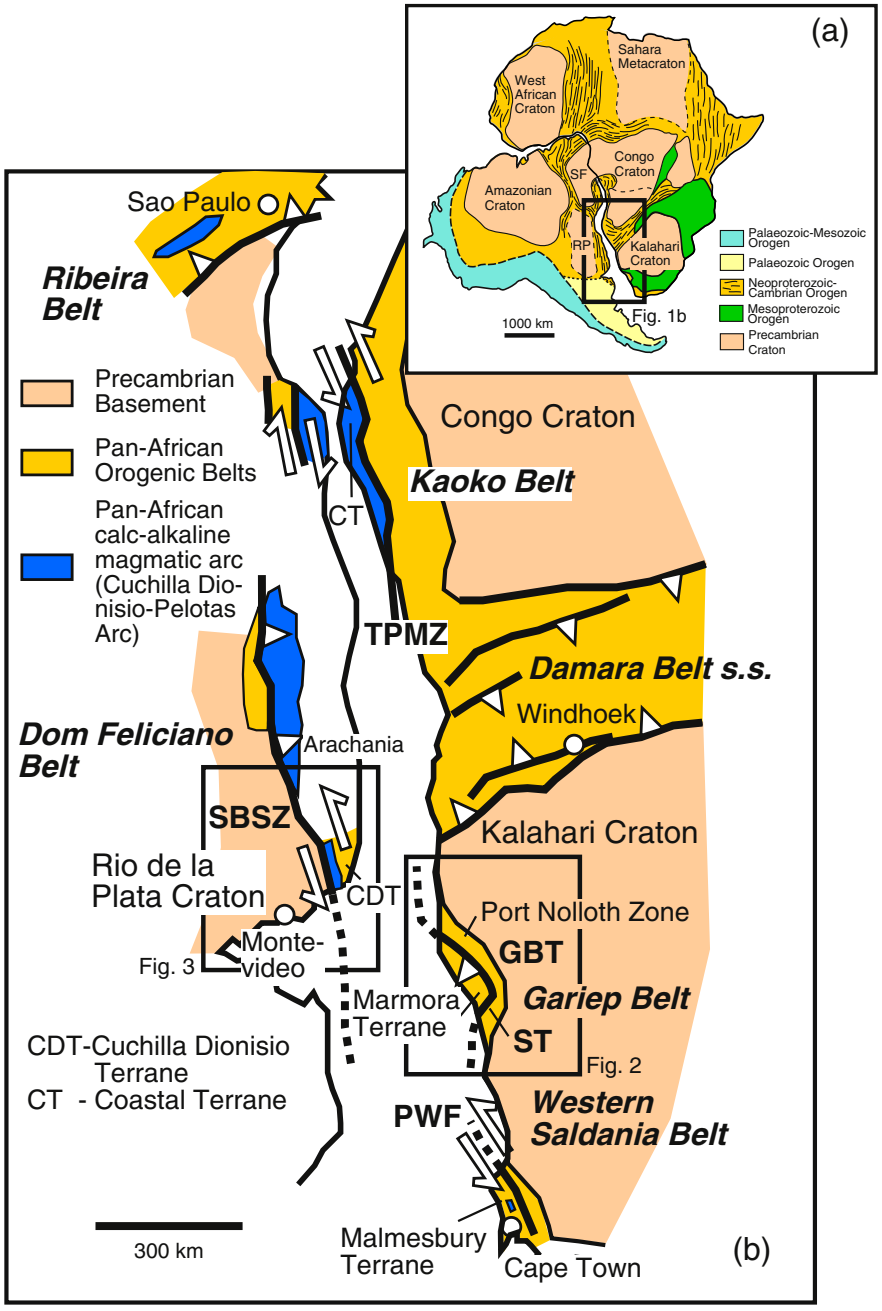


**Fig. 1.** (a) Map of southwestern Gondwana at Ediacaran times (modified after Gray et al., 2008); RP — Río de la Plata Craton, SF — São Francisco Craton. (b) Locations of Pan-African/Brasiliano mobile belts around Precambrian cratonic blocks in southwestern Africa and South America. Also shown is the Early Ediacaran calc-alkaline Cuchilla Dionisio–Pelotas arc (chequered pattern in the print version), part of the Arachania microplate sensu Gaucher et al. (2009) and the major thrust and shear zones that developed during the Late Neoproterozoic and Early Cambrian (modified after Frimmel et al., 2011). South America and southwestern Africa are shown in a Cretaceous rift position. The locations of Figs. 2 and 3 are indicated. GBT — Gariep Base Thrust, PWF — Piketberg–Wellington Fault, SBSZ — Sierra Balena Shear Zone, ST — Schakalsberge Thrust, TPMZ — Three Palms Mylonite Zone.