GEOCHEMICAL AND ISOTOPIC SIGNATURE OF A MESOZOIC 1000 KM–LONG ARCUATE DYKE SWARM IN NE BRAZIL

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Introduction

The Rio Ceará–Mirim magmatism is represented by a giant dyke swarm ca. 1000 km–long (Fig. 1), comprising mafic dolerites with Early Cretaceous age (~130 Ma). Those dykes are intrusive into Precambrian Borborema Province (NE Brazil) spread in a region ca. 5×10^5 km^2, arranged along an arcuate trend (E–W to NE–SW) from the Atlantic coastline towards NW border of the São Francisco craton – it is one of the largest Mesozoic dyke swarms related to the Gondwana breakup.

The dykes are fine– to medium– grained, holo– to hypocrystalline. The common mineral composition includes plagioclase, augite, pigeonite and Fe-Ti oxides. Gechemically, they are dominated by high–Ti tholeiites (TiO_2>2%), followed by low–Ti tholeiites (TiO_2<2%), rare trachyandesites (SiO_2>57%; Fig. 2) and olivine tholeiites.

In this work we present an integrate characterization of whole–rock geochemistry (major, minor and REE) and Sr–Nd–Pb isotopes of the Rio Ceará–Mirim magmatism.

Methodology

The cartography of the dykes was made combining aeromagnetic data, remote sensing products and field campaigns. Hand samples were collected considering geographic setting besides faciological and compositional variation of lithologies and then analyzed by:

- XRF (major oxides);
- ICP–MS (content of trace elements and REE);
- ID–TIMS (Sr–Nd–Pb ratios).

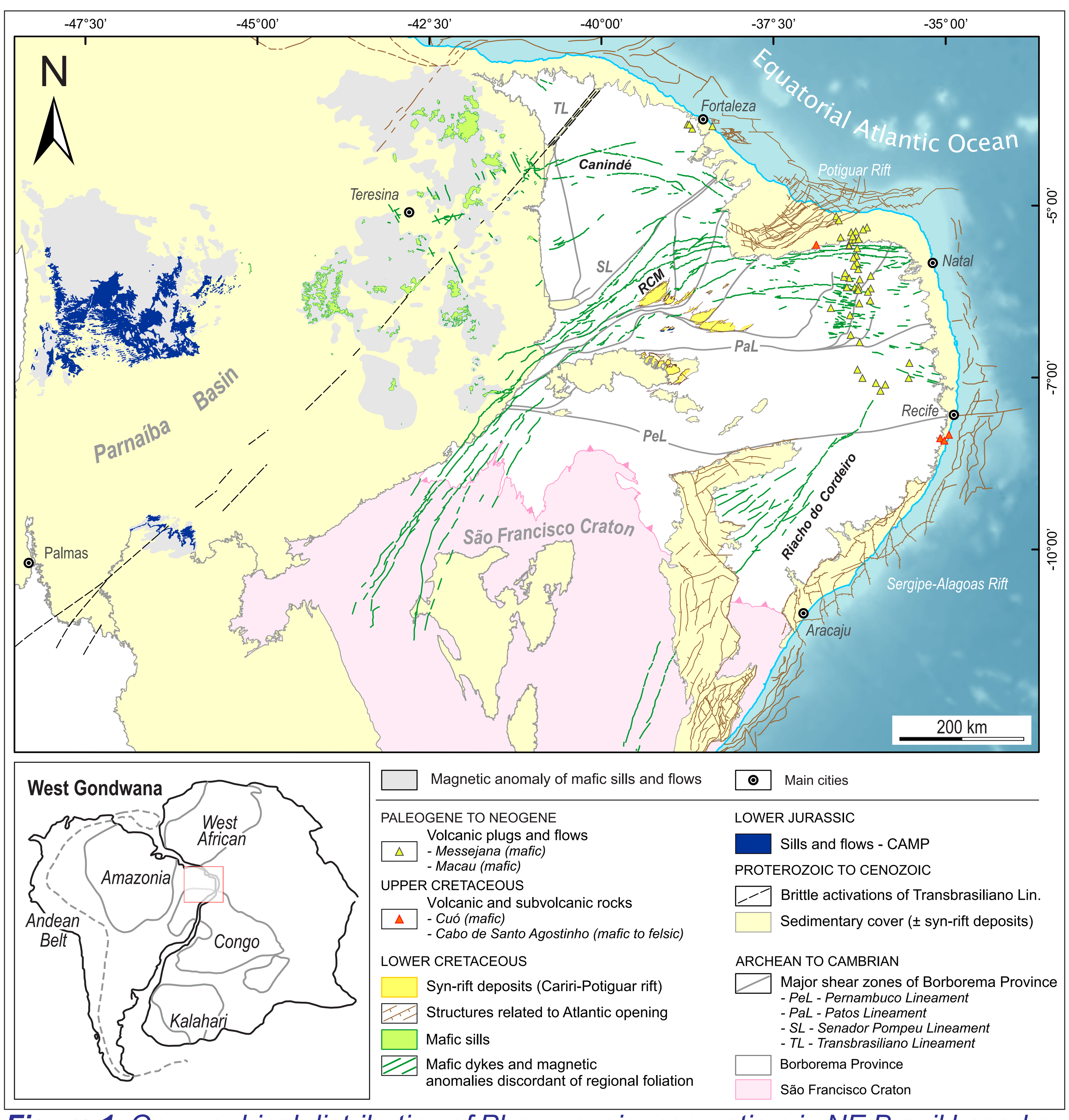

Figure 1. Geographical distribution of Phanerozoic magmatism in NE Brazil based on Hollanda et al. (2019).

Results

On the TAS diagram high–Ti tholeiites are spread though the fields of basalts–basaltic andesite–basaltic trachyandesite and minor trachybasalts (Fig. 2), while low–Ti tholeiites are basalts to basaltic andesites. Rb, Ba, Pb enrichments combined to Nb-Ta depletion are common to all geochemical groups (Fig. 4) suggesting evolution from enriched lithospheric sources also suggested by Th–Nb content (Fig. 3). Isotope parameters (initial $^{143}Nd/^{144}Nd$, $^{87}Sr/^{86}Sr$ and Pb/Pb ratios) for the high–Ti tholeiites are (average values; Fig. 5 and 6): 0.512340, 0.70600, $^{206}Pb/^{204}Pb$ ~ 17.60, $^{207}Pb/^{204}Pb$ ~15.50 and $^{208}Pb/^{204}Pb$ ~37.50.

Low–Ti tholeiites, in turn, are characterized into two slightly different groups: (i) Milhã type composed by dolerites with MgO<4.5 wt.% and average initial $^{143}Nd/^{144}Nd$ 0.512260 and (ii) Pio IX type with dolerites showing MgO>6.4 wt.% and $^{143}Nd/^{144}Nd$ 0.512420. Initial Sr and Pb ratios are quite similar in both low-Ti types ($^{87}Sr/^{86}Sr$ ~0.70800, $^{206}Pb/^{204}Pb$ ~18.20, $^{207}Pb/^{204}Pb$ ~15.60, $^{208}Pb/^{204}Pb$ ~38.40). A third group of trachyandesites (initial $^{143}Nd/^{144}Nd$ 0.512320, $^{87}Sr/^{86}Sr$ 0.70800, $^{206}Pb/^{204}Pb$~ 17.90, $^{207}Pb/^{204}Pb$ ~15.57, $^{208}Pb/^{204}Pb$ ~37.90) is recognized in spatial and genetic relationship with the high-Ti dolerites, which are modelled as products of fractional crystallization from high-Ti magmas.

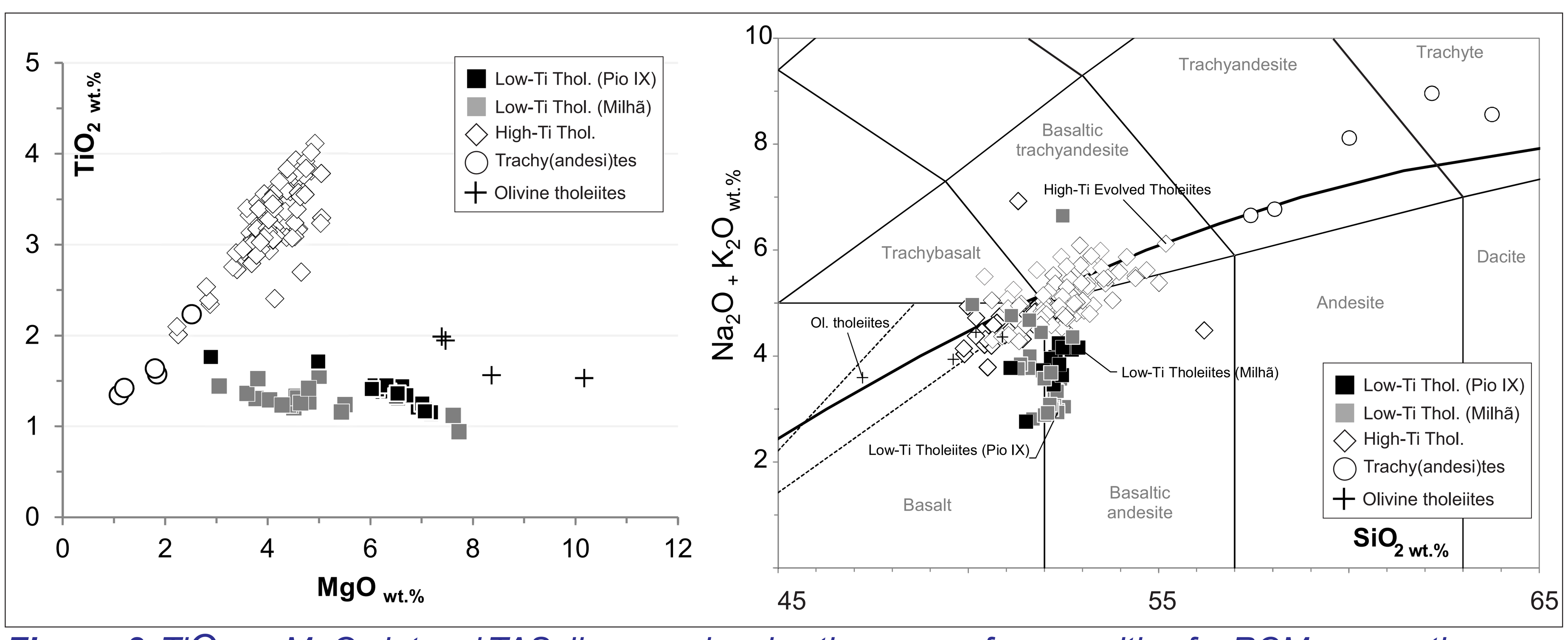

Figure 2. TiO_2 vs. MgO plot and TAS diagram showing the range of composition for RCM magmatism.

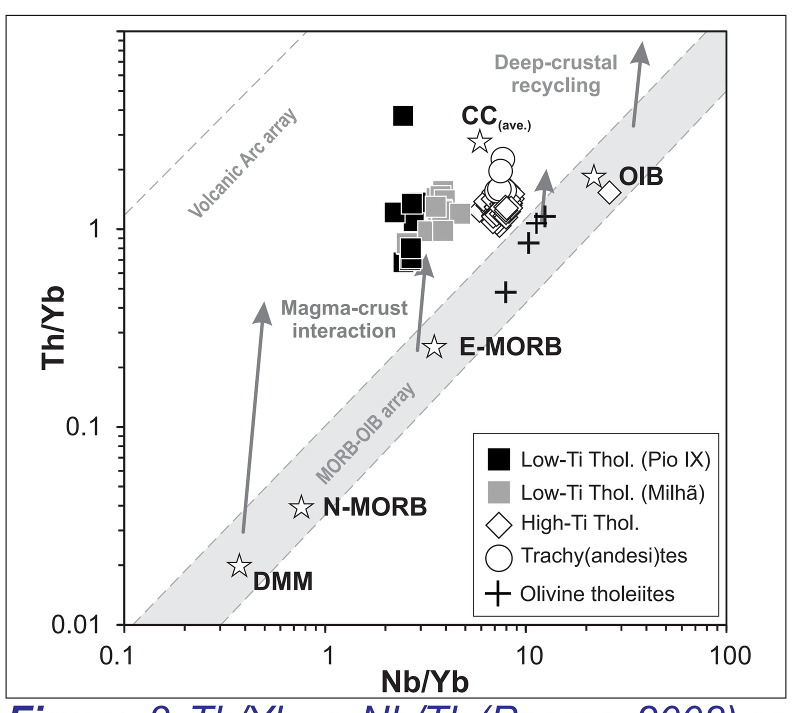

Figure 3. Th/Yb vs. Nb/Th (Pearce, 2008) as proxy for crustal input.

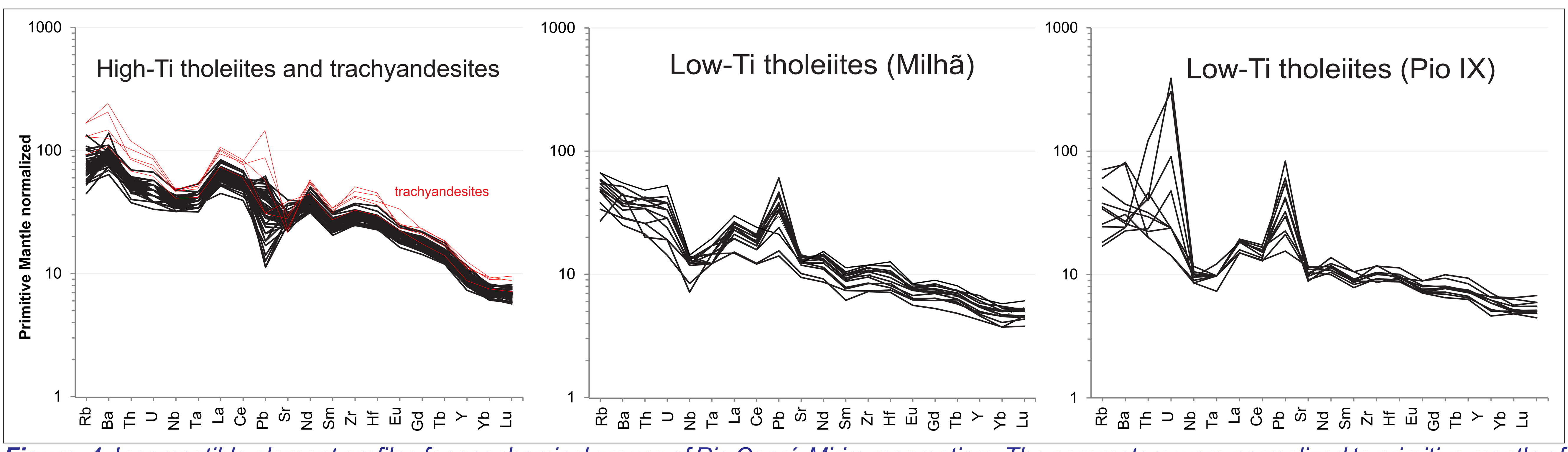

Figure 4. Incompatible element profiles for geochemical groups of Rio Ceará-Mirim magmatism. The parameters were normalized to primitive mantle of Sun and McDonough (1989).

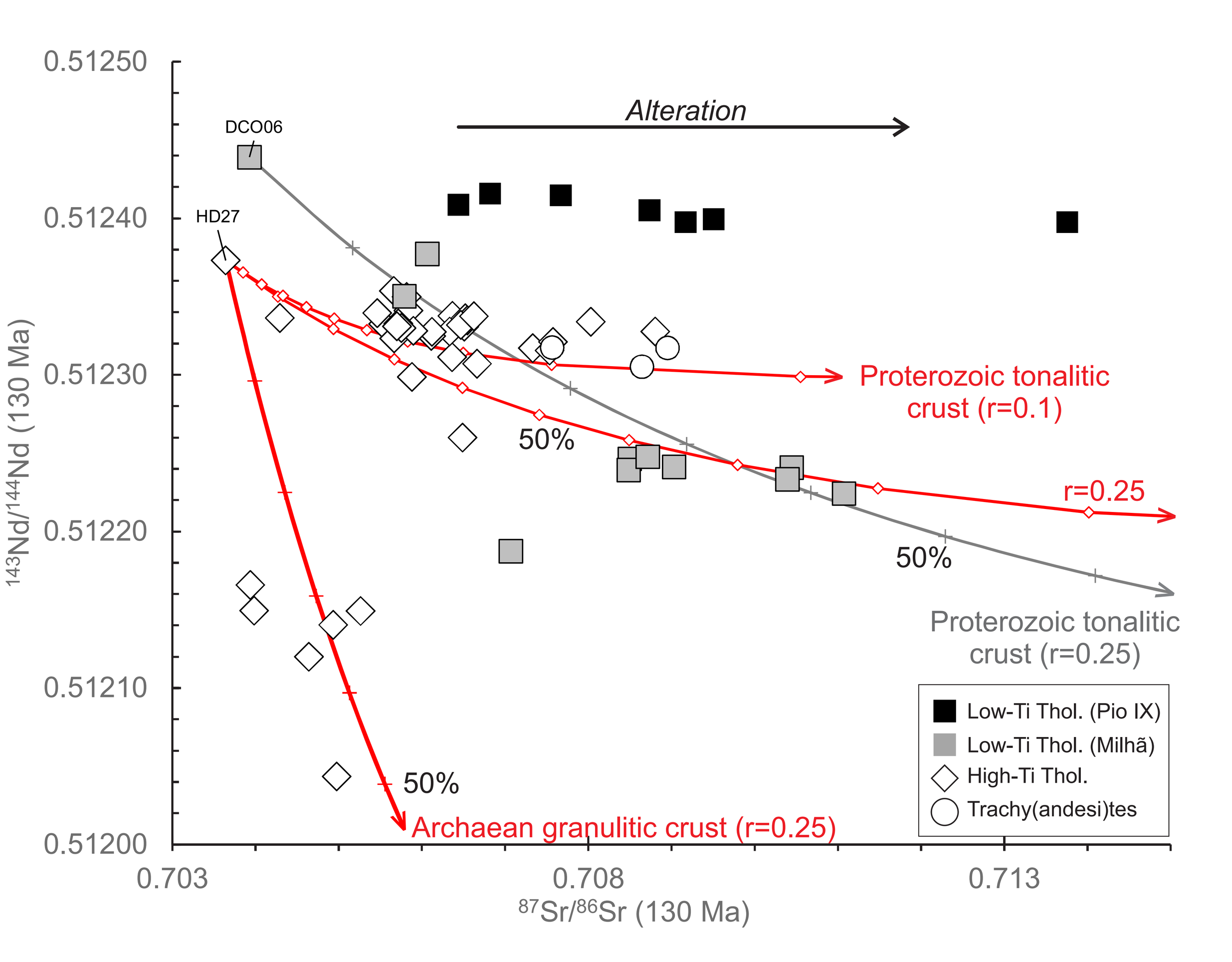

Figure 5. $^{87}Sr/^{86}Sr$ vs $^{143}Nd/^{144}Nd$ plot of Rio Ceará-Mirim dykes. The red and gray curves represent AFC vectors. Mafic tonalite from Ceará Central domain was taken as representant of proterozoic crust, while a granulite sample from São Francisco Craton was considered as archaean crust contaminant.

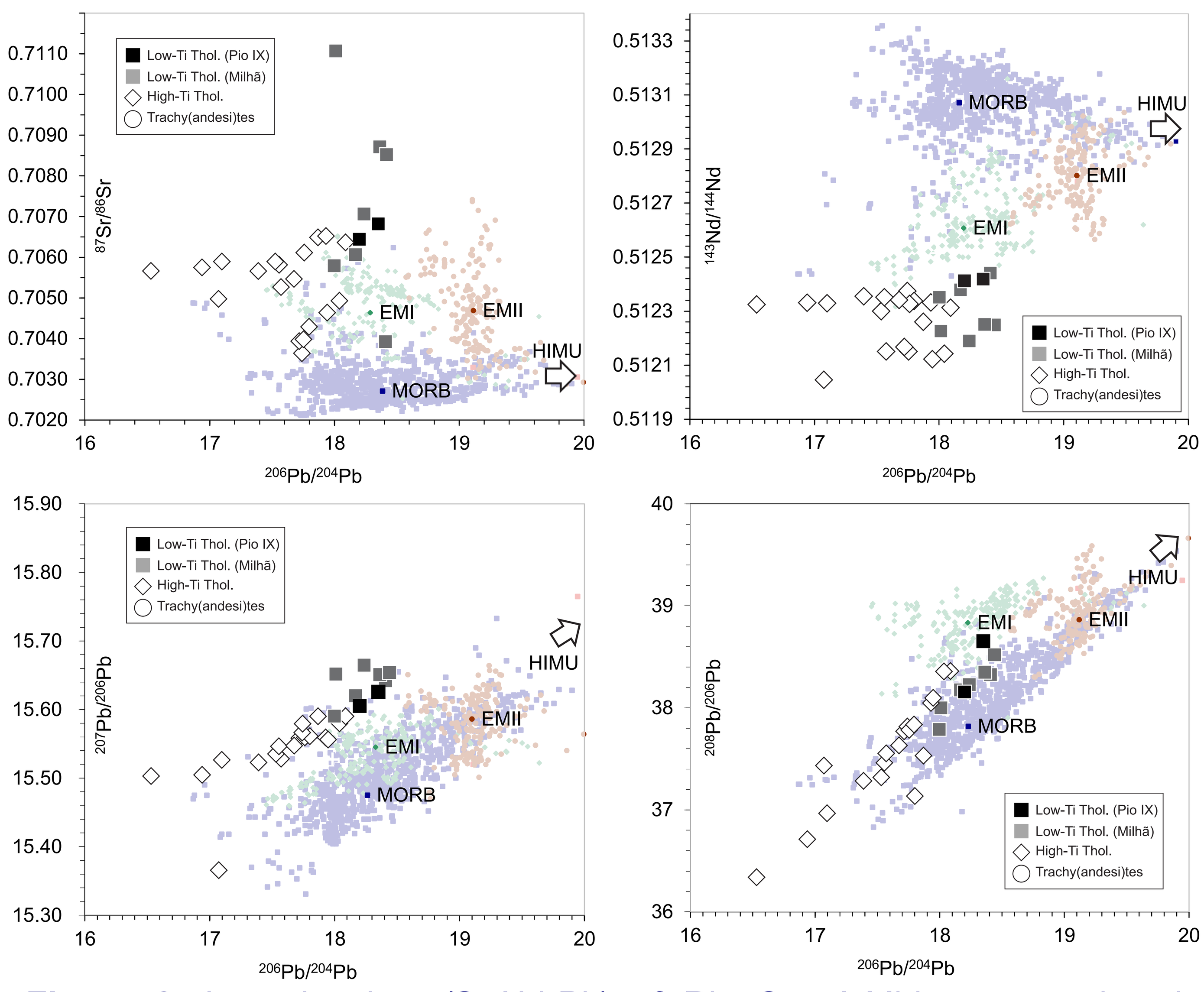

Figure 6. Isotopic plots (Sr-Nd-Pb) of Rio Ceará-Mirim magmatism in comparison with mantle end-members (kimura et al., 2016).

Conclusion

The Borborema Province has not only recorded the effects of several convergence and collisional events associated to the Brasiliano/Pan-African event (650-550 Ma) to form the West Gondwana supercontinent, but also of crustal accretion in the Paleoproterozoic. In that complex geodynamic setting, subduction followed by slab dehydration and some degree of crustal contamination (during emplacement) were certainly responsible to chemically modify the lithosphere towards an enriched signature, that is very close to modern subarc-type mantle sources. Nd model ages calculated for the Rio Ceará-Mirim dolerites range from ca. 1.5 to 1.0 Ga indicating that the mantle reservoir melted to generate their parental magmas was, at least in part, an ancient mantle. This is fully compatible, therefore, with existence of an enriched mantle long-term (EMI-like) preserved from Proterozoic to Mesozoic times beneath NE Brazil. In addition, possible asthenospheric contribution is suggested by part of olivine tholeiites from EW–RCMDS (Ngonge et al., 2016a). In this scenario, primitive melts could have had mixing with enriched components derived from fertile portions of the SCLM to give rise RCM magmatism.

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References

- Hollanda, M. H. B. M., Archanjo, C. J., Filho, A. A. M., Fossen, H., Ernst, R. E., Castro, D. L., Melo, A. C. C., Oliveira, A. L. (2019). Dyke Swarms of the World: A Modern Perspective. Springer Singapore. https://doi.org/10.1007/978-981-13-1666-1
- Kimura, J., Gill, J. B., Skora, S., Keken, P. E. V., Kawabata, H. (2016). Origin of geochemical mantle components: Role of subduction filter. Geochemistry, Geophysics, Geosystems.17(8), 3289-3325. https://doi.org/10.1002/2016GC006343
- Ngonge, E. D., de Hollanda, M. H. B. M., Archanjo, C. J., de Oliveira, D. C., Vasconcelos, P. M. P., & Muñoz, P. R. M. (2016). Petrology of continental tholeiitic magmas forming a 350-km-long Mesozoic dyke swarm in NE Brazil: Constraints of geochemical and isotopic data. Lithos, 258–259, 228–252. https://doi.org/10.1016/j.lithos.2016.04.008
- Pearce, J. A. (2008). Geochemical fingerprinting of oceanic basalts with applications to ophiolite classification and the search for Archean oceanic crust. Lithos, 100(1–4), 14–48. https://doi.org/10.1016/j.lithos.2007.06.016
- Sun, S. -s., McDonough, W. F. (1989). Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. Geological Society, London, Special Publications, 42(1), 313–345. https://doi.org/10.1144/GSL.SP.1989.042.01.19

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