GEOCHEMISTRY AND SM-ND ISOTOPIC DATA FOR DOLERITES OF THE AVANAVERO LIP IN MATTHEWS RIDGE, GUYANA.

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INTRODUCTION

Avanavero mafic dykes and sills are widespread in the Amazonian craton, South America. Although the complete extent of Avanavero magmatism is currently unclear, it has been found in places where it hadn't been previously mapped (e.g.: Matthews Ridge, NW Guyana, the focus of this study). The 1.79 Ga Avanavero event has also been proposed to be linked with similar age units in the formerly adjacent West African craton (Baratoux et al. 2019). A continental rifting origin was suggested by Choudhury and Milner (1971), however, Gibbs and Barron (1993) proposed that a weak juvenile Paleoproterozoic lithosphere undergoing partial melting generated the Avanavero magmatism. Because of its widespread distribution Ernst and Buchan (2001) inferred that it was a Large Igneous Province (LIP) caused by a plume rising from deep mantle. Our goal is to further evaluate the origin of the Avanavero rocks.

We present new geochemical, U-Pb geochronology and isotopic data from unmetamorphosed diabase units from a previously unmapped area in NW Guyana which we correlate with the Avanavero LIP. The geochemistry and radiogenic isotope composition of these diabase samples were integrated with Avanavero geochemistry from elsewhere in Amazonia and this dataset is being used to characterize the source characteristics and differentiation history of the Avanavero LIP.

MATERIALS AND METHODS

A total of 53 mafic and ultramafic rocks were collected during one fieldtrip to NW Guyana (Fig. 1). 18 hand samples were grouped as possibly being part of the Avanavero group and are the focus of this abstract. The geochemical analyses of major, minor, trace and REE were determined by Inductively Coupled Plasma (ICP) Spectrometry by ALS Canada Ltd. For Nd whole-rock isotopic work, the samples were prepared and analyzed by a ThermoFinnigan Neptune MC-ICP-MS at the Isotope Geochemistry and Geochronology Research Centre (IGGRC), at Carleton University, Canada. For the geochronology analysis, U-Pb measurements were acquired using a CAMECA1290-HR secondary ionization mass spectrometer (SIMS) at the University of California, Los Angeles (UCLA), United States.

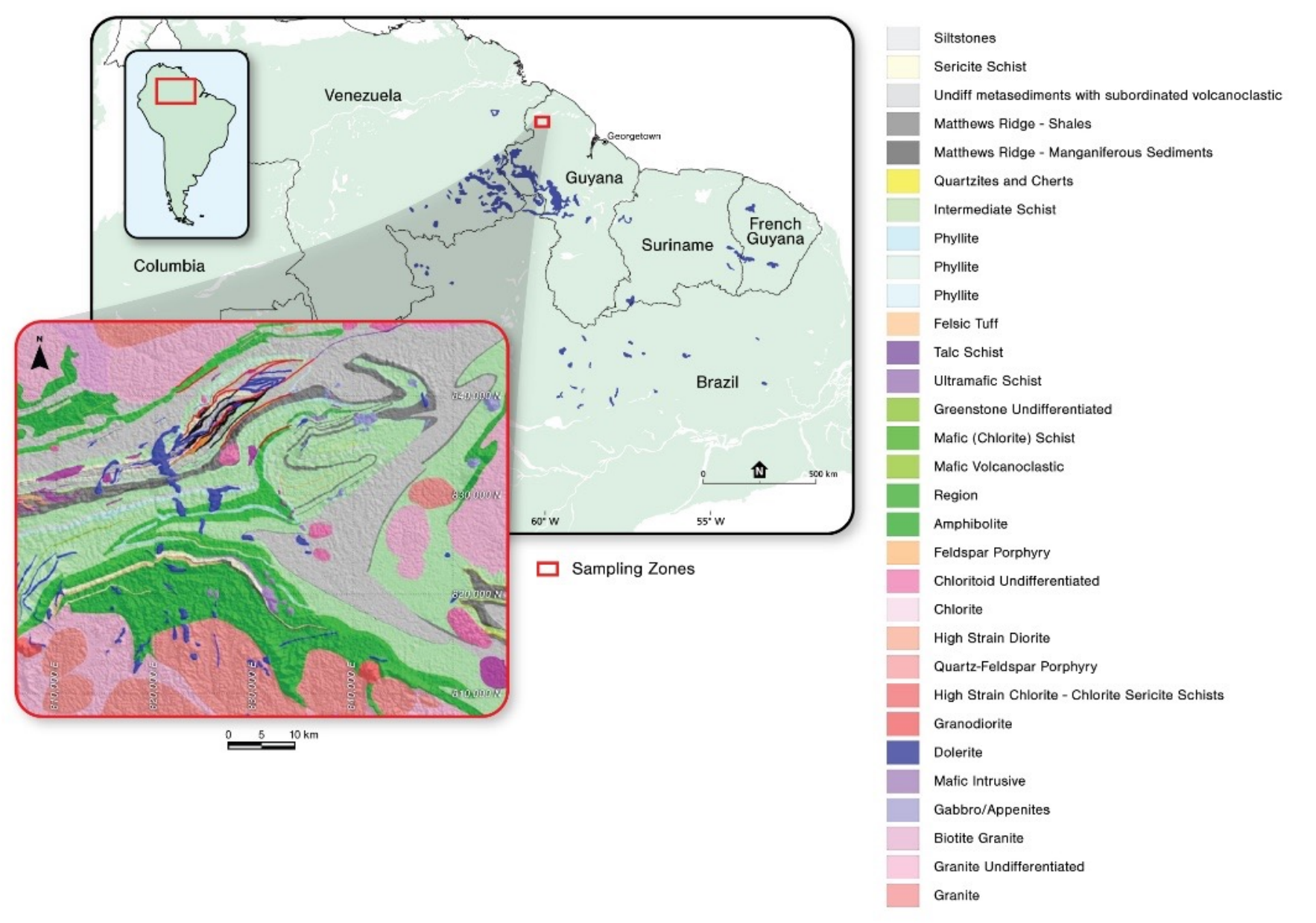


Fig. 1. Detailed sampling zone map provided by FQM (First Quantum Minerals exploration mining company). The navy-blue units in the Guiana shield map represent the Avanavero LIP event. This data was modified from Kroonenberg et. al., 2016.

PETROGRAPHIC DESCRIPTIONS

The Avanavero rocks from NW Guyana have petrographic characteristics similar to other Avanavero locations in the Amazon shield. Plagioclase is the most abundant phase, followed by pyroxene and opaque minerals (magnetite and ilmenite). The plagioclase is labradorite and occurs mostly as subophitic laths enclosing crystal of pyroxene (Fig. 3), however, the opposite can also be seen. The pyroxenes are augite (Ca-rich) and pigeonite (Ca-poor), orthopyroxene was not present, and some samples show pseudomorph crystals.

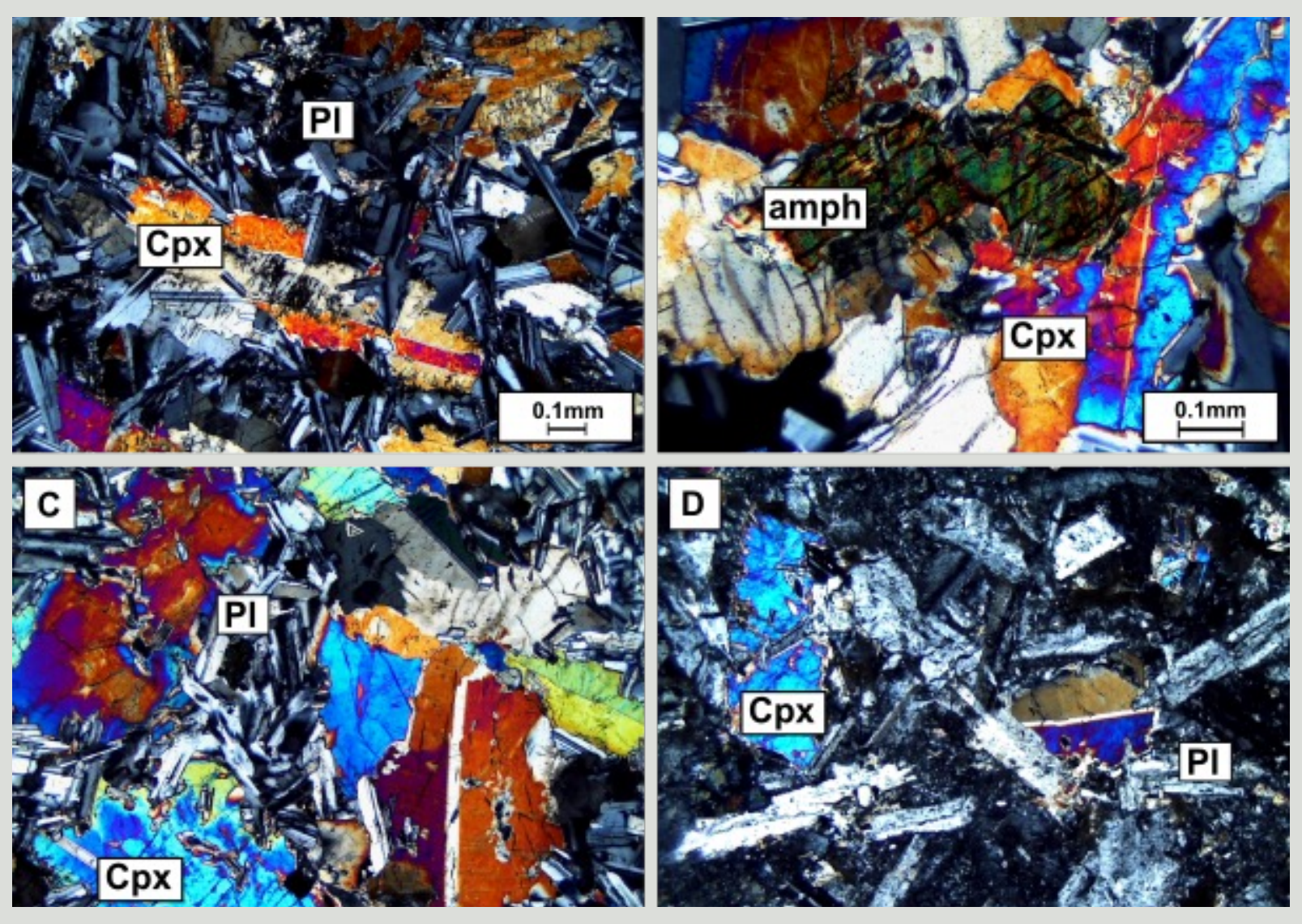
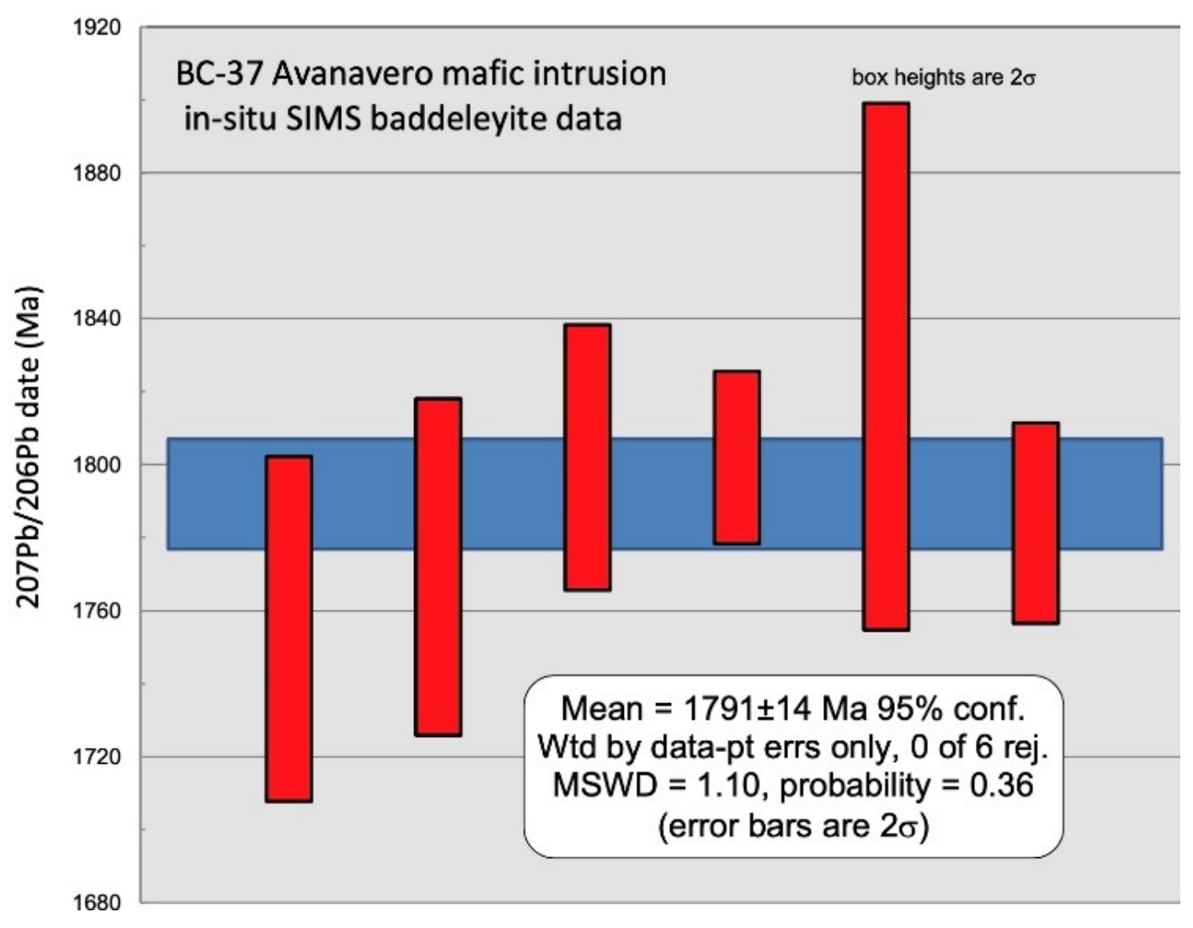


Fig. 2. Photomicrographs of the interpreted Avanavero samples of this study, in cross-polarized light. From A-C: the freshest samples showing medium-grained (A) to coarse-grained (B,C) subophitic texture established by the relationship between laths of plagioclase and Ca-rich/poor clinopyroxene crystals; and substitution of clinopyroxene by amphibole (B). (D): shows that although some alteration can be seen through thin sections, it still preserves its igneous texture between plagioclase and clinopyroxene. Pl: plagioclase, Cpx: clinopyroxene, amph: amphibole, Ser: sericite.

U-PB GEOCHRONOLOGY

The most precise ages obtained using baddeleyite crystals from an Avanavero intrusion in northern Brazil are 1795 ± 2 Ma and or 1793 ± 1 Ma obtained by ID-TIMS. However, younger ages ranging from 1780 to 1782 Ma obtained by SHRIMP have been reported in the past for the Avanavero event (Reis et al., 2013), that could either result from a larger analytical error compared to the ID-TIMS results or represent a younger pulse which would indicate a longer Avanavero event of about 15 Myr.



For this study, three samples were chosen for in-situ U-Pb measurements by a secondary ionization spectrometer (SIMS) to confirm that the Avanavero rocks at Matthews Ridge, Guyana, are indeed of Avanavero age. Some analytical issues were encountered during our analysis, and only one reliable age was determined from the three samples. From sample BC-37, seven baddeleyite grains were analysed with only one showing unacceptably high 204Pb, and the six low-204Pb grains yield a weighted mean 207Pb/206Pg age of 1791 ± 14 Ma, which is in agreement with the U-Pb baddeleyite ages from Reis et al.

SM-ND ISOTOPIC GEOCHEMISTRY

Analysis of Sm-Nd isotopes have been done on nine samples from NW Guyana. Four samples used in Reis et. al. (2013) were provided for the present study by the Geological Survey of Brazil (CPRM-Manaus) to be compared with the NW Guyana samples. The Sm-Nd results obtained for the Avanavero samples of NW Guyana and from Brazil show no significant variation in the initial 143Nd/144Nd ratios (0.511811 to 0.512128), and that their initial εNd values range from -0.7 to +0.6. When plotted against La/Sm and Th/La, initial εNd values show scattered positive and negative pattern, respectively, with only a couple of samples from Brazil being off the trend (not shown here). The initial εNd values when plotted versus the size of their Nb values (Nb/Nb*) show a poor positive correlation (not shown here). No clear crustal contamination trend is observed, although all of the samples may include a small crustal contribution. We interpret the low Th/La and εNd values that cluster around 0 to indicate an ancient, enriched lithospheric mantle source for Avanavero magmas.

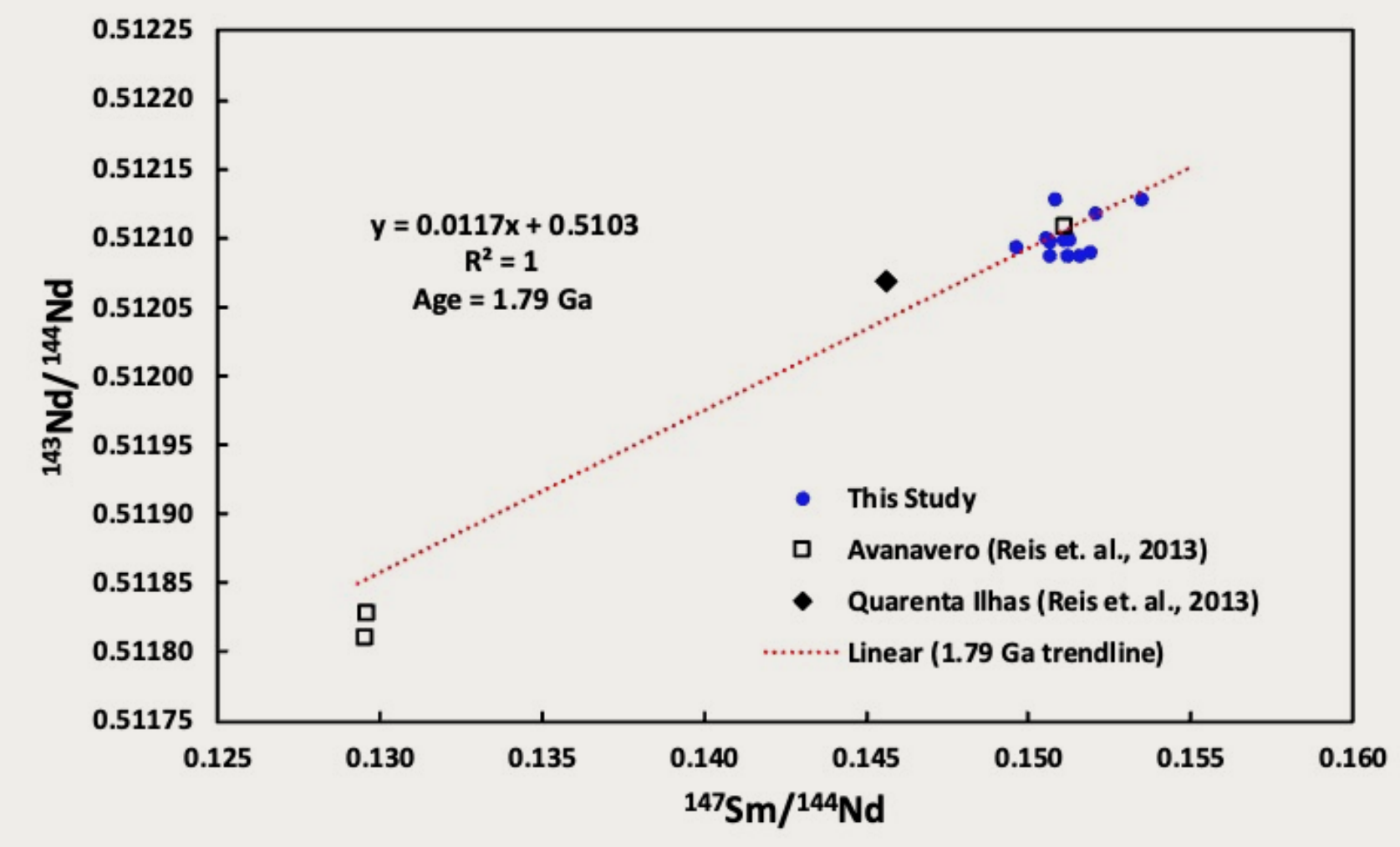


Fig. 4. Present-day 143Nd/144Nd versus 147Sm/144Nd diagram showing that, with one exception, the samples from Brazil and from NW Guyana form two clusters, with no clear isochron. The two clusters are consistent with two different magma batches from a similar source. It also shows a reference isochron with a slope corresponding to an age of 1.79 Ga that passes through the main sample cluster.

WHOLE-ROCK GEOCHEMISTRY

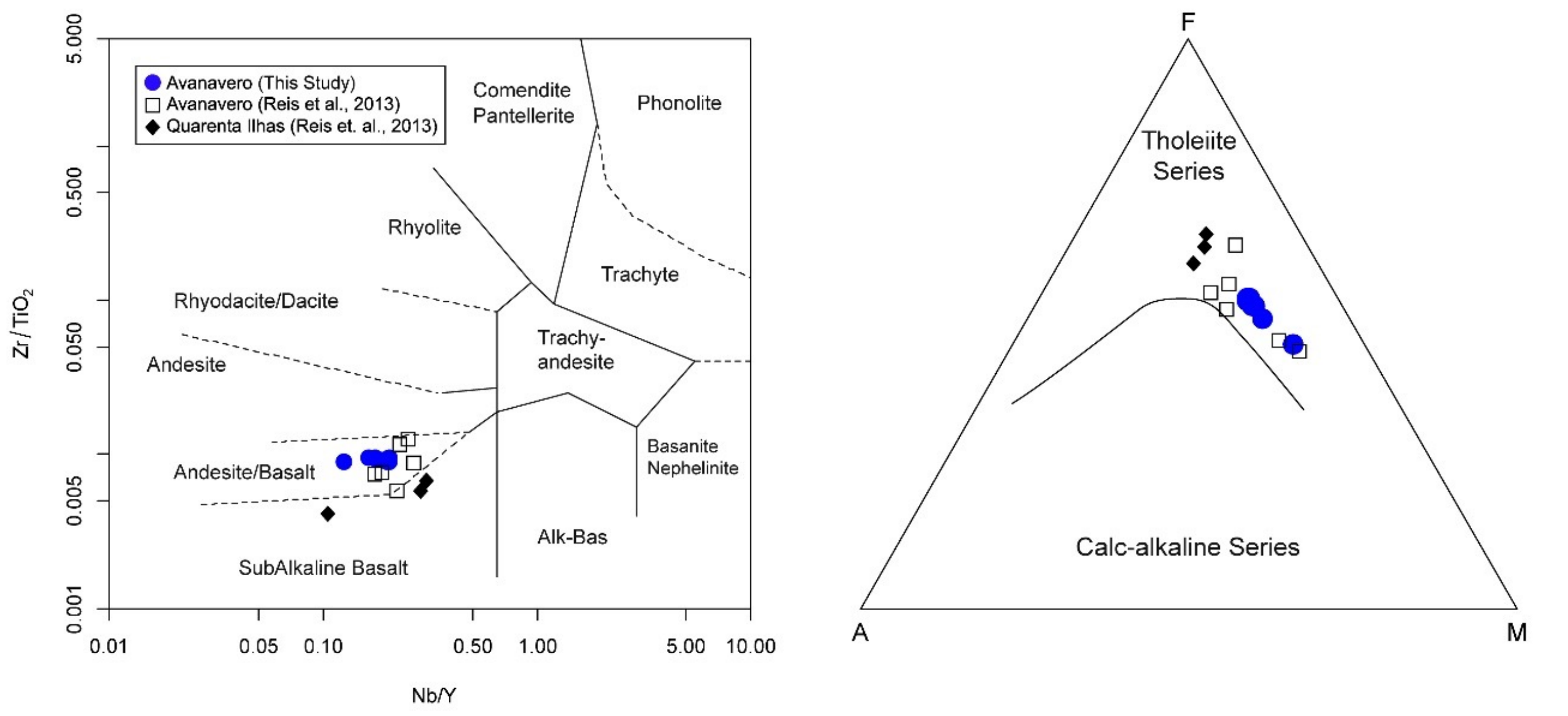


Fig. 5. Dolerite samples from NW Guyana, and Avanavero samples published in Reis et. al. (2013) plotted on Zr/TiO2 vs. Nb/Y (Winchester and Floyd, 1977) in (A) and (B) AFM diagram (Irvine and Baragar, 1971) show that all samples vary from tholeiitic andesitic basalts to basalt. A=Na2O+K2O; F=Fe2O3; and M=MgO.

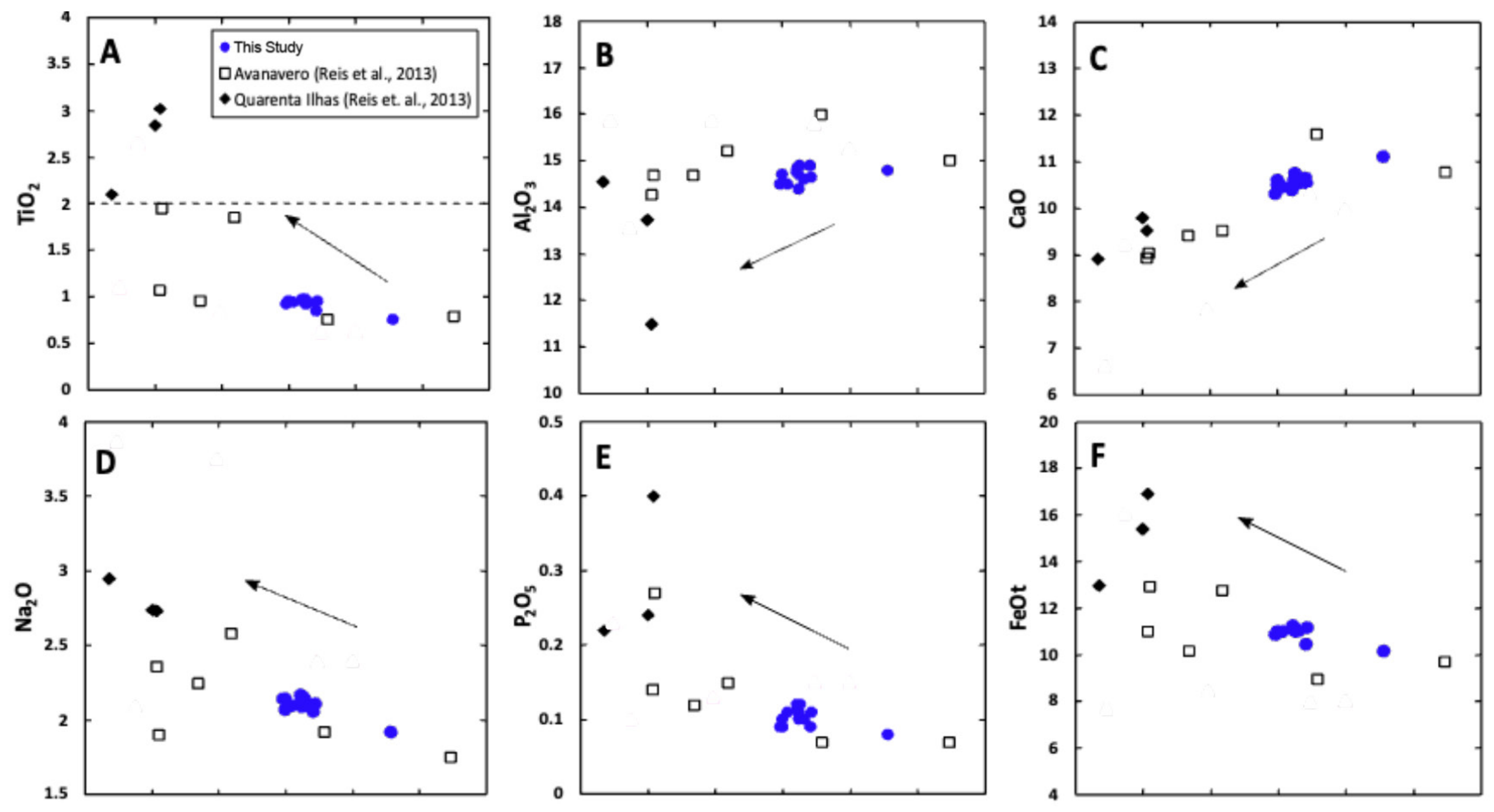


Fig. 6. Harker diagrams for major and trace elements. In the overview of the Avanavero event by Reis et. al. (2013), samples were divided into low-TiO2 and high-TiO2, which would represent the bulk of Avanavero samples and the Quarenta Ilhas group, respectively. In the present study all samples belong to the low TiO2 group. These binary diagrams also show that the samples from NW Guyana follow the same trend formed by the Avanavero samples published by Reis et al. (2013). Arrows show possible differentiation trends.

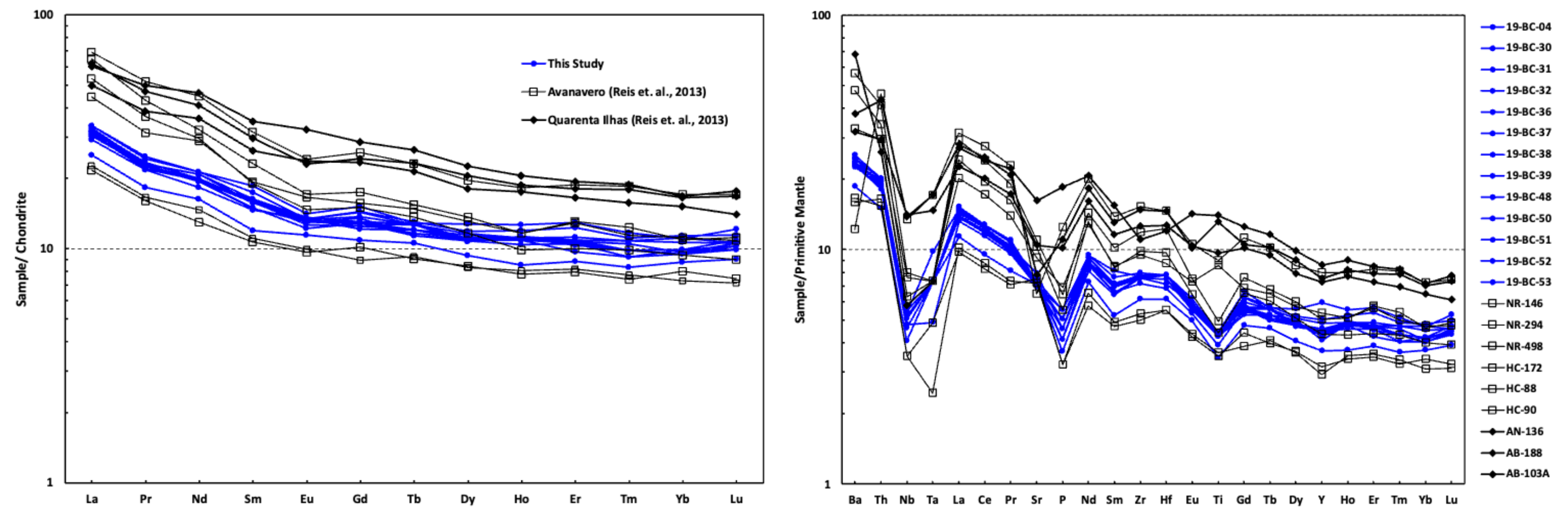


Fig. 7. The chondrite-normalized diagram for the Rare Earth Elements (REE - Boynton, 1984) and the Primitive Mantle-normalized multielement diagram (Sun and McDonough, 1989) show that all samples from this study follow the same patterns seen in Reis et. al. (2013), a slight enrichment in the light-REE relative to the heavy-REE, and negative anomalies of Nb and Ti.

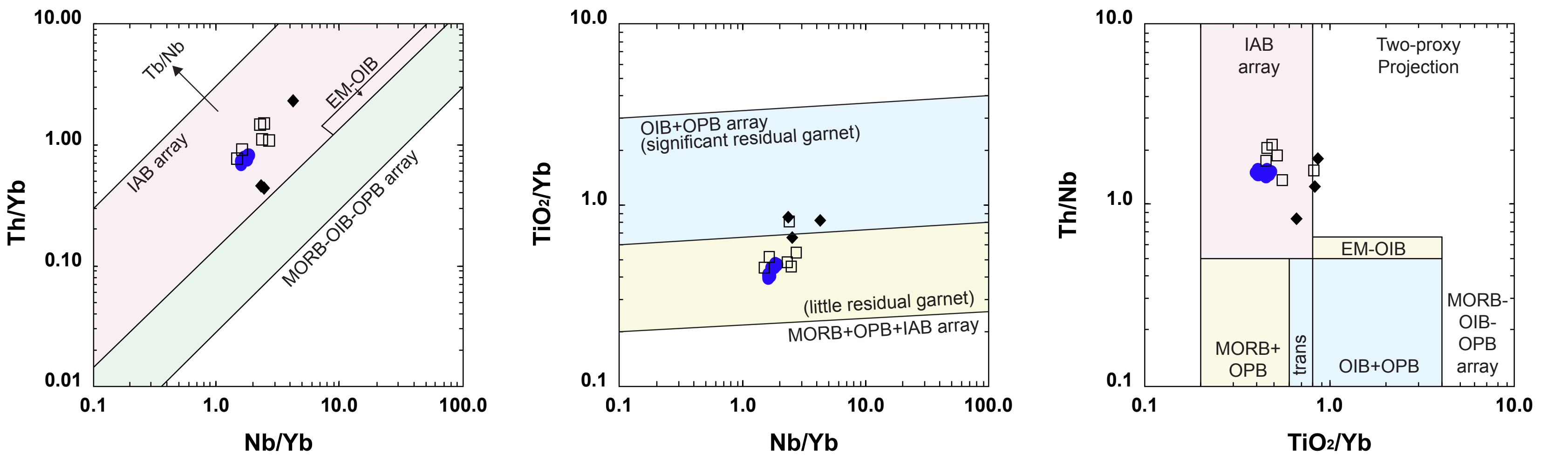


Fig. 8. According to Pearce et. al. (2021), the Th/Yb vs. Nb/Yb projection is sensitive to a magma that has interacted with a continental crust or with a lithospheric mantle that had been previously metasomatized, causing the compositions to move to the IAB (island arc basalts). The interpreted Avanavero samples from this study and from Reis et. al. (2013) plot in the IAB, suggesting a source related to a subduction modified lithospheric mantle. As for the TiO2/Yb ratios, a few samples from the Quarenta Ilhas region plot within the OIB+OPB (Ocean Island Basalts + Oceanic Plateau Basalts) array (Pearce et. al., 2021).

CONCLUSION

Our analyses of samples of Avanavero dolerites from the Matthews Ridge area, NW Guyana, combined with Avanavero samples from Brazil (Reis et. al., 2013) allows us to conclude:

- The date acquired for sample BC-37 overlaps within error both the SHRIMP and the ID-TIMS ages reported by Reis et. al. (2013). Therefore, it is not possible to differentiate whether there are two different pulses or not, however, it is possible to confirm that the unmetamorphosed dolerites from NW Guyana are part of the Avanavero LIP.
- The depletion of high field strength elements (HFSE), such as Nb and Zr, relative to the light-REE, is consistent with a mantle source that has been modified by subduction-related processes.
- The LIP-printing diagram by Pearce et. al. (2021) shows that a magma that has interacted with a continental crust or with a lithospheric mantle that had been previously metasomatized will cause the magma compositions to move to the IAB field (= SZLM, subduction modified lithospheric mantle) which is the case of all samples from NW Guyana and Brazil.
- The low Th/La and εNd values that cluster around 0 suggest an ancient, enriched lithospheric mantle source for Avanavero magmas.
- A few samples from the Quarenta Ilhas region plot within the OIB+OPB (Ocean Island Basalts + Oceanic Plateau Basalts) array, which could indicate that they originated from a different depth and degrees of mantle partial melting when compared to the main Avanavero group (Pearce et. al., 2021).
- Different degrees of partial melting or a different fractionation path could affect the Sm/Nd ratio, however, would not affect the initial εNd values. The similar initial εNd values forming two different clusters in the 143Nd/144Nd versus 147Sm/144Nd diagram suggests that we could be dealing with two slightly different magma batches that came from the same source by potentially different degrees of partial melting or a different fractionation path.

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