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Contrasting Archaean (2.85-2.68 Ga) TTGs from the Tróia Massif (NE-Brazil) and their geodynamic implications for flat to steep subduction transition

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Abstract

We present field, U-Pb zircon geochronology and geochemical data from grey gneisses and amphibolites from Tróia Massif of Northern Borborema Province, NE-Brazil. U-Pb zircon dating of the gneisses indicate two different episodes of Archaean crust formation, represented by the Mombaça (2.85-2.77 Ga) and Pedra Branca (2.70-2.68 Ga) units. Gneisses from Mombaça unit have high content of SiO_2 (64.4-75.4 wt.%), Na_2O (3.28-5.01 wt.%), Al_2O_3 (13.7-17.2 wt.%) and low MgO (0.24-2.60 wt.%) and ∑HREE combined with $(La/Yb)_N$ ratios varying from 6 to 118. In general, these geochemical features are in agreement with patterns of Archaean TTGs younger than 3.5 Ga and high-silica adakites, generated by partial melting of hydrous mafic rocks having garnet as a residual phase. Although high-SiO_2 samples of the Pedra Branca grey gneisses have similar geochemical characteristics to those of Mombaça unit, most samples have higher values of MgO, Sr and compatible elements (Ni-Co) indicating contrasting sources and/or petrogenesis, and thus should be referred to TTG-like gneisses. The lower SiO_2 content of the Pedra Branca TTG-like gneisses coupled with higher values of MgO, Ni, and Co preclude direct melting of meta-mafic rocks, but is suggestive of interaction with peridotitic mantle components. The Mombaça TTGs are better classified as medium-pressure TTGs derived from melting of a garnet-rich, but plagioclase-poor amphibolite. We argue that the higher geothermal gradient required for the formation of these medium-pressure TTGs could be achieved in a flat subduction setting, explaining not only the its geochemical features but also the absence of a constituted mantle wedge. The residual garnet within the subducting slab coupled with eclogitization would raise the density and trigger the slab retreatment and deepening the subduction zone. This would allow the formation of an incipient mantle wedge, and continuous TTG magmatism would fertilize the mantle, that was subsequently involved in the petrogenesis of the younger Pedra Branca unit. Mafic dykes with E-MORB composition yielded a Paleoproterozoic age at ca. 2.03 Ga with inherited zircons from the host gneiss at ca. 2.85 Ga, indicating thus no relation with TTG magmatism.

Key words: TTG, Archaean, Flat subduction, Borborema Province

1. Introduction

How, when and why plate tectonics operated in early Earth are among the most intriguing and difficult questions to be answered by modern geodynamic studies. Certainly, it was different from our modern perspective of plate tectonics, potentially due to contrasting thermal regimes and rock chemistry (Brown, 2006; van Hunen and van den Berg, 2008; Palin and White, 2016). Indeed, Archaean mantle was hotter than it is today, as evidenced by liquidus temperatures and MgO contents of basaltic lavas through time (Abbott et al., 1994; Grove and Parman, 2004; Herzberg et al., 2010; Jaupart et al., 2007). This high temperature regime is attributed to more accretionary heat and a greater amount of heat-producing radioactive elements that had not yet decayed (Korenaga, 2006). Despite the occurrence of older and hotter eclogites or high-pressure granulites (Li et al. 2015; Volodichev et al., 2004), it has been argued that the first appearance of low-temperature/high-pressure rocks during the Neoproterozoic marks the onset of modern plate tectonics dominated by the subduction of colder slabs (Stern, 2005; 2007, Ganade et al., 2014a). On the other hand, mineral equilibria modeling of high-MgO oceanic crust that existed on the early Earth point out that mineral