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3.3 Ga Intraplate Volcanic-Plutonic System of the Gavião Block, São Francisco Craton, Brazil: Implications for Paleoarchean Crustal Growth

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High-silica rhyolites occur along the eastern border of Gavião Block (Brazil) associated with the Contendas-Mirante and Mundo Novo supracrustal belts. Two rhyolite occurrences are characterized by typically magmatic zircon grains having U-Pb ages of 3303 ± 11 Ma. The rhyolites show well-preserved primary features, such magma flow texture and phenocrysts of β-quartz and feldspar. However, in contrast with many Archean greenstone sequences, they are not interlayered with mafic to intermediate units and are rather associated with granitic massifs with identical zircon crystallization ages of ca. 3293 ± 3 Ma and plotting along the same chemical trends as the rhyolites. The rhyolites and granites therefore provide an inter-related plutonic-volcanic system, being an excellent natural laboratory to investigate tectono-magmatic processes at a key time in Earth history.

High emplacement temperatures for the rhyolites are indicated by petrographic evidence (β-quartz phenocrysts), zircon saturation temperatures in the range of 915 to 820 °C, as well as geochemical data, especially high SiO_2 (74-79 wt. %) together with elevated $Fe_2O_{3(T)}$ (~3 wt. %), MgO (0.5-1.5 wt. %) and low Al_2O_3 (<11 wt. %). Negative $\varepsilon Hf_{(3.3)}$ from 0 to -7 and comparable ranges in incompatible trace element ratios (La/Yb_N 4.8 ± 1.8; Eu_N/Eu^* ~0.55) indicate derivation from similar crustal sources for both rhyolites.

The 3.30 Ga rhyolites and granite of the Gavião Block represents part of a plutonic-volcanic system evolved at an intracontinental tectonic setting related to gravitational collapse of a newly thickened continental crust. Specifically, the rhyolites would have derived from extraction and eruption of highly silicic residual liquid formed by crystallization of granitic magma in a relatively shallow (<10 km) reservoir, now represented by the granite massifs. The granite, arriving as a magma or even a liquid, formed by melting and differentiation of material similar to the diorite gneiss that occurs regionally.

The 3.30 Ga plutonic-volcanic system occurs after a period of continuum crustal growth related to the 3.43-3.32 Ga TTG and calk-alkaline magmatism in the Gavião Block. The results on the 3.30 Ga rhyolite-granite systems, together with our new data on 3.43-3.32 Ga magmatism, suggest continuum pressure conditions of melting during continental thickening; since the role of restitic garnet ± rutile, progressively associated with some amphibole and complete absence of plagioclase, through the appearance and the increasing whole of plagioclase as a restitic phase.

We argue that the thickening of continental crust increases total heat production within the upper part of the nascent lithosphere, inducing thermal pulse that generates a wave of crustal anatexis and consequent downward heating of the lithospheric mantle. Crustal melting advectively concentrates radiogenic elements towards the surface, and the upward migration of radiogenics was followed by cooling of the lower crust and lithospheric mantle, causing further strengthening. This mechanism allows for the stabilization of a thick and cool lithosphere with low surface heat flow, which characterizes the modern cratons. Our results suggest that similar mechanism resulted in the cratonization of the Gavião Block ca. 3.3 billion year ago.