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Apatite compositions as tracers of magmatic evolution and potential mineralization in the alkaline rocks from the Pariquera-Açu Suite (SP, Brazil)

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Apatite elemental compositions, when integrated with host rock geochemical data, provide valuable insights into magmatic processes. However, studies of apatite in alkaline rocks formed in extensional settings remain rare, despite the potential of these systems to host economically significant accumulations of critical rare earth elements (REE). Apatite is, in fact, one of the primary REE-hosting minerals in these rocks. Here, we employ electron probe microanalysis (EPMA) and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to investigate the magmatic evolution of the Pariquera-Açu Suite (São Paulo, Brazil) through apatite chemistry. This intrusion represents a fossilized magma chamber characterized by abundant evidence of open-system processes at both macro- and micro-scales, making it an ideal setting for examining apatite crystallization under dynamic conditions. Apatite is the dominant accessory mineral in the suite and occurs in large prismatic, small prismatic, and acicular habits, with compositional variations dependent on the host rock facies. By integrating host rock textures and geochemical data with apatite composition, we distinguish four associations: (1) Apatite crystals from shonkinite/ol-bearing clinopyroxene and cumulate malignite facies, with predominantly large prismatic habits. These apatite grains exhibit high Cl contents under volatile-undersaturated conditions and display REE patterns similar to their host rocks. This composition reflects magmatic evolution governed by fractional crystallization within a magma chamber. (2) Apatite grains from pegmatoid shonkinite/malignite facies that show lower Cl contents, indicative of crystallization under volatile-saturated conditions. This stage leads to the formation of magmatic breccias. (3) Apatite grains from inequigranular malignite facies, with acicular and small prismatic forms, mainly included in felsic minerals. These apatite crystals display intermediate to low Cl contents, crystallized under sub-saturated to saturated conditions. Their distinct REE patterns, relative to their host rock (including negative Eu anomalies) suggest modification by recharge events and hybridization processes that influenced both the REE signature and volatile exsolution. (4) Apatite crystals in the hybrid nepheline syenite facies, with prismatic habits, either enclosed in mesostasis or within biotite crystals, which are extremely enriched in Sr (~3 mass %) and depleted in Ca. Their compositions resemble apatite grains typical of carbonatitic rocks, likely reflecting a localized immiscibility process and potential mineralization. Our results demonstrate the broad applicability of apatite composition in deciphering magmatic processes in alkaline rocks.

Keywords: Apatite composition, alkaline rocks, magmatic processes, Pariquera-Açu Suite.

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