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Accessory minerals within plutonic xenoliths reveal time-integrated processes in the oceanic volcanic island of Fernando de Noronha (Brazil)

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Plutonic xenoliths hosted within volcanic successions provide a valuable archive of time-integrated magmatic processes that occur at depth within the feeder systems of ocean islands. We present new petrographic, whole-rock geochemical, Sr-Nd-Hf isotopic, and U-Pb geochronological data for kaersutite diorite xenoliths hosted in a pyroclastic deposit in the basal Remédios Formation, Fernando de Noronha Archipelago (FNA), Southwest Atlantic Ocean. It consists primarily of andesine, kaersutite, diopside, phlogopite, with minor magnetite and ilmenite, and accessory apatite, titanite, and zircon. Whole-rock geochemistry shows silica-undersaturated, alkaline compositions overlapping with the Remédios Formation and OIB-like trace element concentrations enriched in LREE. These data suggest that these rocks represent xenoliths derived from the same magmatic system which was responsible for the Remédios volcanism. Sr-Nd isotope compositions ($^{87}Sr/^{86}Sr_{(i)}$ = 0.70462–0.70480; εNd = +1.7 to +2.2) indicate derivation from a dominantly depleted mantle source modified by enriched components. In situ zircon $\varepsilon Hf_{(t)}$ values (+2.3 to +5.4) support a mixed mantle source involving depleted mantle and metasomatized subcontinental lithospheric mantle. Zircon U-Pb dating yields a weighted mean $^{206}Pb/^{238}U$ age of 13.60 ± 0.11 Ma, representing the oldest crystallization age yet reported for FNA and extending the known onset of magmatism. Combined titanite-apatite U-Pb data yield a lower intercept age of 9.76 ± 0.94 Ma, which we interpreted as recording a younger thermal event, probably related to the explosive volcanism of the host pyroclastic deposit. These results reveal a protracted magmatic history involving early plutonic crystallization at depth followed by later eruptive reactivation. These ages increase the overlap between FNA magmatism and the onshore magmatism found in northeastern Brazil, adding nuance to the classical fixed deep-mantle plume model. Instead, both isotopic and temporal data are consistent with the melting of depleted mantle, metasomatized by enriched lithospheric components, possibly related to small-scale upper-mantle convection and recycling of subcontinental materials related to the EMI component. These findings refine the temporal framework of FNA alkaline magmatism, providing insights into mantle source characteristics and intraplate magmatic processes in the South Atlantic region, both onshore and offshore and highlight the importance of plutonic xenoliths for reconstructing the early stages of ocean island evolution.