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Long-lived lower crustal magma storage in Southeast Asia: insights from the 1883 Krakatau eruption

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Caldera-forming eruptions in Southeast Asia represent some of Earth's most hazardous volcanic events, yet major gaps persist in quantifying how long magmas reside in lower-crustal mush zones and how rapidly they are assembled into shallow silicic reservoirs before eruption. Here we address these gaps using trace element diffusion modeling in zoned plagioclase crystals from the 1883 Krakatau eruption. Plagioclase crystals from 1883 pyroclastic density currents deposits are characterized by a broad compositional spectrum from An_{35} to An_{92} (with the anorthite content An = Ca/[Ca+Na+K] in mol.%), highlighting repeated recycling of crystals between mafic lower-crustal mushes and evolved upper-crustal reservoirs, similar to other Southeast Asian caldera-forming eruptions. High-An, Mg-rich plagioclase crystals show large intercrystal Mg variability (~120–520 ppm at $An_{90–92}$). Crystals with the highest Mg record crystallization from mafic melts, whereas lower-Mg counterparts reflect subsequent re-equilibration during prolonged upper-crustal storage. High-anorthite plagioclase cores with low Mg contents (<200 ppm) that are linked to mafic melts stored in the lower crust instead record recycling within trans-crustal mush systems and long residence times of 10^4–10^6 years in evolved silicic melts. The inferred trans-crustal architecture and storage durations at Krakatau volcano, based on the shared spectrum of plagioclase anorthite contents, are consistent with those observed for Samalas, Batur, Tambora, Taal and Pinatubo volcanoes, implying that long-lived lower-crustal mush zones and recycled crystal cargoes are common features of caldera-forming systems in the Sunda and Luzon arcs.