

In-situ U-series dating of zircon core-to-rim inclusions in K-feldspar megacrysts reveals protracted growth at super-solidus conditions

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We present in-situ U-Pb and U-Th ages of zircon inclusions (20 – 100 mm in diameter) from core to rim in a single 8 cm-large K-Feldspar megacryst from the 32.9 ka dome eruption of Taápaca volcanic complex (Central Andes, Chile). These large sanidine crystals formed in a rhyodacite magma and later erupted in a hybrid dacite after magma mixing just prior to ascent. The zircon inclusions in the sanidine core (n = 13) attained ^{238}U - ^{230}Th secular equilibrium with U-Pb dates of 530 ± 35 – 950 ± 35 ka. Only few zircons in the megacryst mantle yielded U-Th isochron ages of 155 (+14/-12) – 339 (+70/-42) ka (n = 4) whereas the majority (n = 10) are again in ^{238}U - ^{230}Th secular equilibrium with U-Pb ages of 333 ± 13 – 480 ± 43 ka. Rim-hosted zircons (n = 16) are significantly younger compared to zircon inclusions from the crystal's interior with ^{238}U - ^{230}Th disequilibrium indicating ages of 58 (+12/-11) – 251 (+112/-54) ka. Thus, zircon continuously crystallized and became successively trapped throughout the protracted growth history of the megacryst. Within the four largest individual zircons, the age differences between the zircon cores and rims indicate a maximum range of 30–50 ky of zircon growth before their entrapment into the sandidine megacryst.

The pre-eruptive residence timescale for the K-feldspar is obtained from the duration of c. 500–920 ky for zircons trapped in the core to the youngest zircon in the rims which crystallized c. 25 ky before eruption, suggesting prolonged crystal growth of several hundreds of thousands of years in the rhyodacite host magma. Because these durations agree extremely well with our independent Ba-diffusion timescales for the host K-feldspar and other megacrysts from the same dome eruption, at least 500 ky of megacrystic growth is indicated at hot magmatic conditions. The zircon ages, when combined with magmatic temperatures (740 – 820 °C) as applied in the diffusion model and the pressures (1 – 2 kbar) from amphibole-inclusion-thermobarometry, imply protracted “hot” magma storage at upper crustal levels in continental arc settings.