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Magma Dynamics beneath the Askja Volcanic System across the 1875 Eruption

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Large volume silicic eruptions are relatively rare in oceanic rift settings, yet Iceland's Northern Volcanic Zone (NVZ) repeatedly produces such events within a plume-ridge environment. The Askja Volcanic System (AVS), linked with two large (VEI~5) eruptions at ~10.9 ka and in 1875 CE, represents one of the most prominent silicic systems in the NVZ and provides an opportunity to evaluate magma transit and assembly phenomena across millennial-scale system evolution. Previous studies have focused on eruption frequency and melt production associated with deglaciation. However, the timing of magma storage and recharge within the plumbing system between major caldera-forming events remains unresolved. Because the volcanic activity at the AVS stretches over interglacial periods, it offers a natural laboratory to evaluate how magma residence evolves across major caldera-forming events while also assessing storage behavior during magmatic episodes not directly linked to deglacial forcing.

Here, we apply olivine Mg–Fe diffusion chronometry from -margin and basaltic eruptive products spanning pre-caldera (>3 ka) and post-caldera stages of the AVS. Target units for this study were chosen from host basalts with ~ 6-8 wt% MgO [3] and relatively homogeneous isotopic signatures [4]. Olivine crystals exhibit compositional zoning (Fo70–Fo83 cores to Fo45–Fo60 rims), recording late-stage chemical modification prior to eruption. One-dimensional diffusion models are applied to concentration profiles using temperature-dependent Fe–Mg diffusion parameters [1] and established diffusion chronometry frameworks [2]. Diffusion modeling of compositional profiles recorded in both the pre- and post-caldera basaltic products is consistent with sub-annual residence times.

Consistent residence times before and after the 1875 eruption suggest magma transit times remain stable despite caldera collapse and associated reorganization of the plumbing system. Such short residence time records are consistent with short-lived shallow storage rather than prolonged crustal accumulation in a vertically extensive magmatic system.

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