Pre-eruptive Timescales from the Hoei Eruption (AD 1707) of Fuji Volcano, Japan

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Major tectonic earthquakes could awaken dormant volcanoes, triggering eruptions after intervals that range from hours to months (Nishimura, 2017; Jenkins et al., 2024). What happens inside a magmatic system during that interval, how ready the system already was for eruption, and why the timing varies so widely remain unclear. The 1707 Hoei eruption of Mount Fuji (VEI 5), the largest historical eruption in Japan, provides a unique opportunity to investigate earthquake–volcano interactions. The eruption lasted approximately two weeks (16 December 1707 –1 January 1708) and began 49 days after the M8.4 Hoei Tokai earthquake on 28 October 1707. The eruption began with a basaltic phase (Unit-0), followed by a dacitic Plinian phase (Unit Ho-I), and subsequently evolved into andesitic (Unit Ho-II) and basaltic (Units Ho-III and Ho-IV) sub-Plinian eruptions (Miyaji et al., 2011; Baba et al., 2022). The involvement of compositionally contrasting magmas implies the activation of multiple magma reservoirs within the Mount Fuji magmatic system. The erupted products preserve clear evidence of magma interaction shortly before eruption, including banded pumice and widespread reverse zoning in phenocrysts. These observations indicate intensified open-system processes prior to eruption, consistent with seismic unrest recorded between the earthquake and the eruption (Miyaji et al., 2011; Tsukui et al., 2024). To investigate the link between the earthquake and volcanic unrest, as well as the duration of pre-eruptive open-system processes, we estimate the timescale from magma injection to eruption using the mineralogical record of the Hoei eruptive products and compare the results with the known 49-day interval.

Olivine phenocrysts from all eruptive units were analysed, and Fe–Mg interdiffusion modelling was applied following a methodological approach similar to that of Couperthwaite et al. (2020). Only crystals exhibiting diffusion zoning at their rims were selected for modelling. The resulting interdiffusion timescales range from 2 to 462 days, with 76% of the estimates falling within the first 49 days and a PDF peak at ~14 days. The estimated diffusion timescales in this study typically had a relative error of approximately 40 %. The dominance of short timescales suggests an intensification of open-system processes immediately prior to eruption, broadly overlapping the 49-day interval within uncertainty.

In the dacitic Ho-I unit, olivine crystals are predominantly normally zoned, with compositional profiles reflecting the combined effects of crystal growth and diffusion that hinder robust diffusion modelling. In contrast, orthopyroxene phenocrysts from Ho-I frequently exhibit reverse zoning at crystal rims, likely associated with late-stage intrusion of hotter magma. Here, we applied a methodological approach similar to that of Kotov et al. (2025). Fe–Mg interdiffusion modelling in orthopyroxene yields timescales of 3–77 days (relative error ~35%), with ~92% of estimates falling within the 49-day earthquake–eruption window and a PDF peak at ~26 days.

Longer timescales derived from olivine (up to 462 days) may indicate that deeper basaltic and andesitic magma reservoirs were already active prior to the earthquake and possibly experienced strong intensification in the period leading up to eruption, as evidenced by the prevalence of short timescales. In contrast, the short diffusion timescales recorded by orthopyroxene in the dacitic unit imply rapid activation of the shallow dacitic magma reservoir shortly before eruption, consistent with the post-earthquake interval of 49 days. Together, these observations suggest that while the Mount Fuji magmatic system was primed before the earthquake, the major seismic event triggered enhanced

open-system processes (e.g., magma mixing and degassing) and likely played a critical role in the activation of the shallow dacitic magma chamber.

Keywords: Fuji Volcano, Hoei Eruption, Hoei Earthquake, Eruption Trigger, Diffusion Modelling