Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35625

Oxygen isotopes reveal narrow temporal and spatial scale of crustal contamination of magmas at Kīlauea volcano after major caldera collapse event

MAHINAOKALANI ROBBINS[1], AARON J. PIETRUSZKA[1], ILYA N. BINDEMAN[2], MAY MAI SAS[3], KENDRA J. LYNN[4], DREW T. DOWNS[4] AND JOHN MICHAEL RHODES[5]

[1]University of Hawai‘i at Mānoa
[2]University of Oregon
[3]Western Washington University
[4]USGS Hawaiian Volcano Observatory
[5]University of Massachusetts - Amherst

Assimilation of hydrothermally altered material is not typically observed within the timescale of active volcanic events. In 2018, Kīlauea’s summit lava lake drained days and the lower East Rift Zone erupted, causing Kaluapele (Kīlauea summit caldera) to collapse. After the eruption, a water lake formed at Kaluapele’s base over ~18 months. In December 2020, fissures formed on the walls of the Kaluapele and lava poured into the caldera from above, causing the water lake to evaporate in ~90 minutes. Tephra from these vents was diverse in texture (i.e., scoriaceous/microlite-rich to pumiceous/glassy). Thereafter, Halema‘uma‘u erupted multiple times (2021–present) with generally glassy tephra.

We compared major (EPMA & WD-XRF) and trace element abundances (LA-ICP-MS), and oxygen isotope ratios ($\delta^{18}O$, $\Delta^{17}O$) of December 2020 and subsequent 2021–25 tephra. Scoriaceous tephra from December 2020 is compositionally heterogeneous (4.1–6.9 wt.% MgO) and extend to lower $\delta^{18}O$ values ($\delta^{18}O$=4.6–5.5‰; n=29), whereas the December 2020 and 2021–25 tephra is slightly more homogeneous (5.8–7.2 wt.% MgO) with a narrower and higher $\delta^{18}O$ range for both the December 2020 glassy tephra ($\delta^{18}O$=4.6–5.5‰; n=29) and the 2021–25 tephra ($\delta^{18}O$=5.3–5.6‰; n=19). Notably, groundmass from eruptive products formed during the initial hours of the first post-collapse eruption (December 2020) were also analyzed for oxygen isotopes ($\delta^{18}O$=0.41–1.94‰ and $\Delta^{17}O_{0.528}$=0.016‰) and are the lowest $\delta^{18}O$ values ever measured for Kīlauea lavas/tephra.

Kīlauea’s mantle source $\delta^{18}O$ is ~5.6‰. Lower $\delta^{18}O$ of Kīlauea lavas are explained by magmas from oceanic basement rock and contamination by the edifice. $\Delta^{17}O$ can be used to determine the temperature of hydrothermal alteration[1], and $\Delta^{17}O$ suggests the December 2020 lava and associated tephra is sourced from a magma body that was contaminated by hydrothermally altered crust at high temperatures (~150°C) related to the presence of the post-collapse water lake. The variation of tephra $\delta^{18}O$ after a major caldera collapse event corresponds to tephra texture, where lower $\delta^{18}O$ scoriaceous tephra represent relatively more contaminated magma. This reveals a narrow timescale (<18 months) and fine spatial scale (within a single sample) of magma contamination with hydrothermally altered crust around a major volcanic event.

[1] Vialichka & Bindeman (2025), *Chemical Geology* 696, 123087.