

Geochemical insight into recent post-caldera collapse eruptions at Kīlauea Volcano

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The historic events at Kīlauea Volcano in 2018 inundated the lower East Rift Zone (LERZ) with $\sim 1 \text{ km}^3$ of lava, deepened the summit crater by $>500 \text{ m}$, and left questions regarding the subsequent state of the summit magmatic system. The degree of disruption of shallow reservoirs was unknown, as were implications for the eventual resumption of eruptive activity.

By late 2020, geophysical data hinted at impending renewal of activity, but geochemical data were steady; CO_2 and SO_2 emissions remained low ($< \sim 50 \text{ t/d SO}_2$) and the newly formed summit water lake showed no departures from existing physical or chemical trends. Ultimately, a summit eruption began on 20 December and continued through May 2021; a second eruption initiated in September 2021.

Various measurements of eruptive plumes revealed bulk gas chemistry of $\sim 86\text{--}90\% \text{ H}_2\text{O}$, $8\text{--}11\% \text{ SO}_2$, and $2\text{--}3\% \text{ CO}_2$. This low CO_2/SO_2 ratio ($0.2\text{--}0.3$) is characteristic of partially CO_2 -degassed magma at Kīlauea, implying that erupting material had previously stalled within Kīlauea's upper reservoir system rather than rising directly from tens of kilometers depth. The lack of precursory degassing also implies magma rose quickly from those stalled depths.

Olivine in December 2020 tephra is normally zoned from Fo_{88} cores to Fo_{82} skeletal overgrowth rims or is non-zoned Fo_{82} with skeletal textures; similar olivine populations are found in September 2021 tephra. Fo_{82} is in Fe-Mg equilibrium with the host glass in each eruption ($\text{MgO} = 6.9 \pm 0.4 \text{ wt\%}$ for December 2020; $6.8 \pm 0.3 \text{ wt\%}$ for September 2021). Though high-Fo cores indicate hotter, and presumably deeper, prior storage (e.g., South Caldera reservoir; $3\text{--}5 \text{ km}$), Fo_{82} rims imply both eruptions were fed by the Halema'uma'u reservoir ($1\text{--}2 \text{ km}$).

December 2020 glass chemistry overlaps with both early 2018 summit lava lake samples and with 2018 LERZ lavas (phase 3). By September 2021, glass compositions align solely with LERZ samples, indicating that the 2020-2021 eruption flushed out older magma from Halema'uma'u, and by September 2021 the system was dominated by the 2018 LERZ phase 3 composition.

Taken together, gas geochemistry and petrology indicate minimal changes to the summit reservoir system despite the 2018 collapse events.