Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24500

Insights into magma storage depths and eruption controls at Kīlauea Volcano during explosive and effusive periods based on melt and fluid inclusions

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Kīlauea Volcano (HI, USA) experiences centuries-long sequences of explosive and effusive eruptive behavior that seems associated with caldera collapse cycles. However, the relations between these eruptive styles and changing conditions in the underlying magma plumbing system remain poorly known. To investigate this, we analyzed olivine-hosted melt and fluid inclusions by FTIR and Raman spectroscopy to determine magma storage depths and compositions during Kīlauea's explosive-era Keanakāko'i Tephra eruptions (~1500–1840 CE)*[1]*, which occurred following a large-scale caldera collapse. We then compare these results to literature estimates for modern effusive-era Kīlauea eruptions (1959 Kīlauea Iki, 1960 Kapoho, 2018 lower East Rift Zone) *[2-7]*.

We find that shallow (1–3 km) magma storage has persisted for centuries at Kīlauea, spanning both explosive (Keanakāko'i) and effusive (modern) periods. In contrast, mid-crustal zones of magma storage have shallowed over time, from 5–8 km during the Keanakāko'i sequence to 3–5 km during the modern effusive period. Many melt and fluid inclusions in high-forsterite olivine (Fo_{86-89}) have shallow entrapment depths, indicating that high-temperature magmas (1200 to ~1300°C) commonly reach depths of ≤3 km at Kīlauea during both explosive and effusive periods.

CO_2-rich fluid inclusions are present in olivine from all investigated Kīlauea eruptions but are larger and much more abundant in Keanakāko'i units. We interpret this as indicating that a greater volume fraction of exsolved CO_2-rich fluid was present in pre-eruptive Keanakāko'i melts compared to the modern effusive-era magmas. Abundant CO_2-rich fluids in the Keanakāko'i-era magmas contributed to their explosivity by increasing magma buoyancy and driving rapid magma ascent, which would have increased eruption energy and enhanced near-surface magma-water interactions in a deepened caldera. We additionally highlight how simple optical petrography of CO_2-dominated fluid inclusions can provide rapid barometric estimates in low-H_2O magmatic systems.

[1] Lerner et al. 2024, *EPSL*, 628, 118579; [2] Anderson and Brown, 1995, *Am. Mineral.*, 78, 794-803; [3] DeVitre and Wieser, 2024, *GPL,* 29, 1-8; [4] Lerner et al., 2021, *Bull. Volcanol.*, 83, 43; [5] Moore et al. 2015, *Am. Mineral.*, 100, 806-823; [6] Tuohy et al. 2016, *GCA.*, 185, 232-250; [7] Wieser et al., 2021, *G3*, 22, e2020GC009364