Petrologic Testament to Changes in Shallow Magma Storage and Transport
Associated with Prolonged Recharge and Eruption at Kilauea

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Abstract

The current history began over 30 years ago with the 1983-1986 eruption of Pu‘u ‘O‘o, the youngest active vent on the east side of Kilauea volcano. The eruption was driven by the recharge of magma in a shallow reservoir. HVO geologists and volcanologists monitored this eruption using a dense network of geophysical and geodetic instruments, hydrothermal wells, and the measurement of trace elements in individual glass and melt inclusions. The data reveal that the shallow reservoir grew in size, age, and temperature over time. The system that fed Pu‘u ‘O‘o eventually recharged to a magnitude of ~10^6 m³, with its size, age, and temperature increasing from 0.2 to 1 km³, 3 to 8 years, and 1170 to 1250°C, respectively. The magma transported through the shallow reservoir via a large open conduit or a small network of conduits. HVO geologists and volcanologists hypothesize that this conduit was a large open system, similar to those inferred for other rift zone eruptions. The conduit is likely to have been formed by a combination of processes, including the recharging of the shallow reservoir, the transport of magma through the shallow reservoir, and the degassing of sulfur-rich magma.

1170°C

Melt Inclusion
Matrix Glass

Ba Th U Ce La Nd Sm Eu Gd Tb Ho Tm Yb Lu Zr Hf

0.27

(KD=0.27, Putirka, 2008)

Variability of sulfur inclusion concentrations among crystals of plagioclase and micro-gabbro clusters with similar inclusions and temperatures in natural rocks and experimental charges low pressure clinopyroxenes in Kilauea lava at low-pressures rift zone.

Rift-zone olivine inclusions range beyond 1000 ppm S magmatic sulfur trapped in melt inclusions can be used to infer plumbing dynamics associated with shallow open-system storage and continuous recharge. A steady trend since the trend of decreasing incompatible elements over time is apparent in ratios of fractionation from melts of ~10 to ~7 wt% MgO. As exemplified by CaO variations assessing magmatic conditions such as low-pressure fractionation, mixing or variation diagrams for major and trace elements provide a first-order means of plumbing dynamics associated with shallow open-system storage and continuous recharge. Forsterite olivine crystals in the mix over time points to a diminishing amount of olivine phenocryst compositions in east rift lava from 1994 through 2012. Phenocrysts with a wide range of temperature-dependent phenocryst core compositions, some are reversed-zoned mixing prior to eruption. Olivine, spinel, clinopyroxene and plagioclase plumbing dynamics associated with shallow open-system storage and continuous recharge. The highest glass temperatures in each sample provide the clearest demonstration of magmatic continuity between the shallow summit and throughout the 18-km-long rift conduit. Trace-element signatures for glasses, glass inclusions and bulk lava in 2008 rift and summit eruptions remain consistent and are compositionally consistent with melt inclusion and matrix glass compositions from 2008.

1050°C

84°C

Temperature of near-equilibrium olivine crystallization. Likewise, the highest glass temperatures in each sample provide the clearest demonstration of magmatic continuity between the shallow summit and throughout the 18-km-long rift conduit. Trace-element signatures for glasses, glass inclusions and bulk lava in 2008 rift and summit eruptions remain consistent and are compositionally consistent with melt inclusion and matrix glass compositions from 2008.

100-250°C

Olivine phenocryst compositions in east rift lava from 1994 through 2012. Phenocrysts with a wide range of temperature-dependent phenocryst core compositions, some are reversed-zoned mixing prior to eruption. Olivine, spinel, clinopyroxene and plagioclase Plumbing dynamics associated with shallow open-system storage and continuous recharge. The highest glass temperatures in each sample provide the clearest demonstration of magmatic continuity between the shallow summit and throughout the 18-km-long rift conduit. Trace-element signatures for glasses, glass inclusions and bulk lava in 2008 rift and summit eruptions remain consistent and are compositionally consistent with melt inclusion and matrix glass compositions from 2008.