Preservation of mantle-derived recharge signatures in olivine during protracted magma storage

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Magmatic recharges underneath basaltic volcanoes can lead to an eruption. However, identifying these events is often challenging, particularly when they are not revealed or ambiguous in the geophysical record. Because primitive melts injected in a magmatic system during recharge are usually rapidly mixed with the stored magma, the primitive nature of the recharge is rapidly lost in the melt compositions. By contrast, major and trace elements from primitive (>Fo_{87}) olivine can preserve the information lost by the melt. The recent 2018 Kīlauea Lower East Rift Zone (LERZ) eruption appears to have unlocked part of the olivine mush pile stored in an undetermined mafic reservoir. The olivine crystals have highly heterogeneous core compositions (Fo_{77-89}) that overlap with olivine compositions from Pu‘u ‘Ō‘ō. This could be the result of mixing between the Pu‘u ‘Ō‘ō magma and the summit reservoir [1]. Here, we examine major and trace elements in olivine and provide the first evidence for a single source from the summit region for all erupted products of the main effusive phase. The absence of clear seismic swarms associated with magma intrusion in the LERZ over the decades preceding the 2018 eruption suggests no progressive magma storage there following the last eruption in 1977. By contrast, increases in seismicity at 5-13 km depth and geodetic data around the summit region during March-April 2018 suggest pressurization of the summit and upper to middle-ERZ regions directly before the 2018 eruption. These episodes of pressurization are interpreted, through prior dissolution fronts preserved only in phosphorus maps in the primitive olivine, as multiple recharge events of primitive magma pulses prior to the eruption. We show that rather than recording different magma compositions originating from separate stored magmas, the variable olivine compositions from 2018 reflect different total duration of storage (several generations of olivine crystals) and partial erasing of their compositional traits by diffusive reequilibration of the entire crystal.

[1] Gansecki et al. Science 366 (2019)