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Years to decades of pre-eruptive storage recorded by olivine from the basaltic subplinian deposit of Kulanaokuaiki Tephra Unit 3 (900 C.E.), Kīlauea Volcano (HI)

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Kīlauea Volcano has recently been recognized as having several centuries-long periods of dominantly explosive eruptions, in striking contrast to modern effusive activity[1]. Of the deposits from the two most recent explosive periods, the Uēkahuna Ash (-200 to 1000 C.E.) is poorly studied relative to the more recent Keanakāko'i Tephra (1500-1820's C.E.). The Kulanaokuaiki Tephra (400-1000 C.E.) member of the Uēkahuna Ash period is composed of 5 stratigraphically recognizable units found primarily across Kīlauea's south flank and includes a basaltic subplinian deposit (Unit 3; 900 C.E.), representing the largest known explosive eruption at Kīlauea[2]. Here we focus on olivine chemistry from Unit 3 to better understand its pre-eruptive magma storage and transport history. Unit 3 olivine crystals are 1-3 mm in diameter and dominated by core forsterite content modes of Fo_{89} (n=148), similar to the dominant composition of olivine from the Keanakāko'i Tephra[3]. The Unit 3 scoria deposit is significantly zoned in whole-rock MgO (7-15 wt%), suggesting evacuation of a chemically zoned magma body[2], but the olivine crystals show no systematic changes in composition throughout the deposit. The crystals are either non-zoned Fo_{88-90} or normally zoned from Fo_{88-90} cores toward Fo_{80-82} rims, suggesting final storage in a shallow part of the plumbing system. The zoned rims are 100-500 μm wide and when modeled yield diffusive re-equilibration timescales (n=34) of several years to several decades. A subset of Unit 3 crystals has additional clear evidence of overgrowth rims ~100 μm wide and yields a second timescale of weeks to months. The absence of bimodal olivine populations and reversely zoned olivine crystals in Unit 3 indicates that magma mixing with a more primitive magma was unlikely. The large crystal sizes and long diffusion timescales suggest that olivine crystals from a mush zone in Kīlauea's reservoir system were transported to much shallower levels before storage for additional years to decades. Their storage may have been further disrupted weeks to months prior to eruption, as evidenced by the overgrowth rims.

[1] Swanson et al. 2014; Geology 42:631-634. [2] Fiske et al. 2019; GSA Bulletin 131:1537-1554 [3] Lynn et al. 2017 CMP 172:76