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Glass chemistry of the Kulanaokuaiki Tephra Units 4 and 5 deposited from explosive eruptions of Kīlauea Volcano (HI)

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Kīlauea Volcano, Hawai'i, has prehistoric explosive periods characterized by large ash plumes and high fountaining events that reveal phases of Kīlauea's cyclic eruptive history not currently observed. Studies suggest that the recent Keanakāko'i Tephra (1500-1820's) were emplaced after significant reservoir/magma supply depletion caused caldera collapse [1]. The older and less-studied Kulanaokuaiki Tephra, a member of the explosive Uēkahuna Ash Period (200 BCE-1000 CE), were deposited from 400 to 1000 CE [2]. The Kulanaokuaiki Tephra is comprised of five distinct units that are located primarily on Kīlauea's south flank. This study presents new major, minor, and trace element concentrations in basaltic glass from upper-Kulanaokuaiki Tephra (Units 4 and 5) to compare the magmatic processes of the two most recent explosive periods at Kīlauea.

We find that upper-Kulanaokuaiki Tephra glass MgO values range from 5.8-12.6 wt%, suggesting different magma storage depths within the Kīlauea crustal reservoir(s), comparable to the Keanakāko'i Tephra (3.4-11.2 wt% MgO) [3]. Thermodynamic MELTS modeling using a 12 wt% MgO parental melt composition show that the upper-Kulanaokuaiki data can be fit with olivine, plagioclase, and clinopyroxene fractional crystallization trends with oxygen fugacity near the quartz-fayalite-magnetite buffer, at 350 bars, and with low water content (0.1-0.2 wt%). This is similar to MELTS modeling of Keanakāko'i Tephra [3].

The upper-Kulanaokuaiki has an overall more depleted trace element signature than Keanakāko'i, based on lower Cr, Ni, Ba, Sr, and Th abundances. These suggest the former is from a slightly different mantle source composition. Trace element ratios such as Nb/Y range from 0.39 to 0.50, lower than those for the Keanakāko'i Tephra (0.50 to 0.58) [3] and much lower than the modern effusive period (0.53 to 0.89) [4]. Lower Nb/Y ratios of explosive periods suggest that a high degree of partial melting produced their parental melts [3]. This contrasts with inferred low magma supply during explosive periods [1] and may be explained by endogenous growth [3].

[1] Swanson et al. (2014) Geology, 42.

[2] Fiske et al. (2009) Geological Society of America, 121.

[3] Garcia et al. (2018) Geological Society of America, 538.

[4] Garcia et al. (2003) Journal of Petrology, 44.