Olivine crystallization pressures within Kilauea's lower east rift zone: the use of rehomogenized melt inclusions to interpret magma transport, storage, and energetic fountaining

Robin M Tuohy[1], Paul J Wallace[1], Donald A Swanson[2]

[1]University of Oregon, USA, [2]Hawaiian Volcano Observatory, USA

E-mail: rtuohy@uoregon.edu

The classic model of Kilauea's eruptive and deformation behavior is based on observations made by the Hawaiian Volcano Observatory during the 1959–1960 eruptions. Although the 1959 Kilauea Iki eruption produced the highest lava fountain observed at Kilauea (580 m), the 1960 Kapoho eruption on Kilauea's lower East Rift Zone (ERZ) produced fountains greater than 400 m in height. A possible explanation for high fountains on the lower ERZ is that they involve a component of undegassed, CO2 rich magma that has bypassed the summit reservoir and shallow rift system. Alternatively, they may involve rapid supply of magma to the rift zone from the summit magma chamber. The goal of this project is to determine if any of the energetic mid 20th century Kilauea eruptions on the lower ERZ were fed by deeply sourced magmas, with high CO2 concentrations, that had bypassed the summit and shallow rift systems. We are investigating this hypothesis by determining crystallization pressures for melt inclusions in olivine from the 1840, 1955 Puna, and 1960 Kapoho eruptions on the lower ERZ. The 1959 Kilauea Iki summit eruption, previously investigated by Anderson and Brown (1993) will represent a summit eruption site. Melt inclusions analyzed for this study were experimentally reheated to 1400℃ for 15 minutes to redissolve the CO2 lost to shrinkage bubbles after entrapment. Our results show that some hydrogen diffusive loss occurs from small inclusions, and we are running additional experiments at lower temperatures and shorter durations to quantify the extent of hydrogen loss. We will also compare our data to Raman measurements of CO2 in bubbles to see if they yield comparable results. Data for natural and reheated Kapoho melt inclusions suggest 50–60% of original CO2 is lost to the shrinkage bubbles, with reheated inclusions ranging from 200 to 1200 ppm CO2, and one value of 2400 ppm compared to 100 to 300 ppm CO2 for natural melt inclusions. The H2O and CO2 contents allow us to calculate the pressures at which the inclusion-bearing olivines formed, and thus infer the pressures of magma storage. Kapoho olivines crystallized between 1 and 10 km depth, and one value at 19 km, with a significant number of olivine having crystallized in the deep rift. The Kapoho olivines are typically Fo89, in contrast to Kilauea Iki olivines (Fo87), many of which have shallower crystallization depths (>1 to 6 km). Therefore, the Kapoho eruption may be more complicated than previously realized. If Kapoho was a simple extension of the Kilauea Iki summit eruption, there should be more overlap in Fo content and crystallization depth. The higher pressures of some reheated inclusions may suggest a source for some olivines that is deeper than the summit reservoir and shallow rift zone.