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Petrology and Geochemical Evolution of Lavas from the Ongoing and Voluminous Puu Oo Eruption of Kilauea Volcano, Hawaii

GARCIA, Michael[1*] ; PIETRUSZKA, Aaron[2] ; GREENE, Andrew[3] ; MARSKE, Jared[4] ; RHODES, Michael[5]

[1]Dept. Geology-Geophysics, Univ. of Hawaii, [2]USGS, Denver, [3]Depart. Natural Sciences, Hawaii Pacific University, [4]Dept. Terrestrial Magnetism, Carnegie Institution of Washington, [5]Dept. Geoscience, Univ. Massachusetts

The Puu Oo eruption of Kilauea Volcano is one of the longest-lived (31 years and continuing) Hawaiian eruptions. Volumetrically, it is the most significant historical eruption. It has produced over 4 km3 of lava from several vents along its east rift zone. We have continually monitored the compositional and isotopic signatures of its lavas, which have shown remarkable variations. These variations resulted from diverse crustal and mantle processes including crystal fractionation, magma mixing and storage, assimilation of crust and melting of a heterogeneous plume source. Crystal fractionation is an important process in these lavas based on their wide range of MgO contents (5-10 wt.%) and normally zoned minerals (mostly only olivine). During the first two years, the effects of crystal fractionation were superimposed on hybrid magmas created by mixing two evolved, rift zone-stored magmas with a new, mantle-derived magma. Later lava erupted show no signs of mixing except for one-day, uprift events in 1997 and 2011. Small, systematic variations in Pb and Sr isotopes, incompatible trace element ratios and MgO-normalized (10 wt.%) major element abundances of post-mixing lavas document rapid changes in the parental magma composition unrelated to crustal processes. Lavas erupted between 1985-1998 continued the post-1924 composition trend of Kilauea lavas towards more depleted composition. This trend was initiated by the collapse of summit crater during a period of very low magma supply. Puu Oo lavas showed a systematic temporal evolution towards historical Mauna Loa lava composition from 1998-2003. This trend reversed in 2003 and again in 2008 creating a cyclic pattern of geochemical variations. These reversals in composition are contrary to previous models for geochemical trends during sustained basaltic eruptions. The cyclic variations of Pb isotopic and some trace element ratios during the Puu Oo eruption suggest melt extraction from a mantle source with thin strands of vertically-oriented source heterogeneities. These strands may be 1-3 km in diameter in order to explain the scale of isotopic variations for the Puu Oo eruption. This continuing eruption provides a dynamic laboratory for evaluating models of the generation and evolution of basaltic magmas.

Keywords: volcano, Hawaii, eruption, historical, magma, basalt