Petrology and geochemical evolution of lavas from the ongoing and voluminous Puu Oo eruption of Kilauea Volcano, Hawaii

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The Puu Oo eruption reached its 30th anniversary in early 2013. Volumetrically, this is the most significant historical eruption of Kilauea having produced 4 km3 of lava from several sites along its east rift zone. Since its start in 1983, we have monitored the compositional and isotopic signatures of its lavas, which have shown remarkable variations resulting 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 Puu Oo lavas based on their wide range of MgO contents (5-10 wt. percent) and normally zoned minerals. The effects of crystal fractionation are superimposed on magmas that initially (1983-85) were hybrids from mixing evolved, rift zone-stored magmas with new, mantle-derived magma. After 1985, lava erupted from two primary vents (Puu Oo and Kupaianaha) and did not have an evolved magma component. Lava erupted during two uprift episodes in 1997 and 2011 was, however, dominated by cooler, rift zone stored magma. Oxygen isotope exchange of Puu Oo magma with hydrothermally altered Kilauea lavas is indicated by the low O isotope values for matrix material and olivines, and the lack of correlation of O isotope values with other geochemical parameters. This exchange probably occurred within the shallow reservoir underlying the Puu Oo vent and has affected most of its lavas. Small, systematic variations in isotopes of Pb and Sr, incompatible trace element ratios and MgO-normalized major element abundances 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 compositions. This trend began just after the collapse of summit crater during a period of low magma supply. From 1998-2003, Puu Oo lavas show a systematic temporal evolution towards historical Mauna Loa lava compositions. 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 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 0.6-2 km in diameter in order to explain the scale of isotopic variations for the Puu Oo eruption. The continuing Puu Oo eruption provides a dynamic laboratory for evaluating models of the generation and evolution of basaltic magmas.