Explosive Summit Collapse of Kīlauea Volcano in 1924 Preceded by a Decade of Anomalous Lava Chemistry

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The first century of Kīlauea’s historical eruptive record was dominated by nearly continuous lava lake activity, mostly within Halema‘uma‘u pit crater. In May 1924, the lava lake within Halema‘uma‘u drained, its floor collapsed, and numerous phreatic explosions occurred. For the next three decades, eruptions were sporadic (the longest hiatus was from 1934 to 1952) and relatively short (typically <1 day long). Kīlauea lavas from ~1820 to 1934 record a temporal increase in ratios of highly to moderately incompatible trace elements (Nb/Y or La/Yb) that is thought to result from a factor of ~2 decrease in the degree of partial melting of a more refractory mantle source. This correlates with a decline in the eruption rate, and presumably, the magma supply rate to the volcano. Here we show that the Pb and Sr isotope ratios of lava and tephra glass samples erupted at Kīlauea’s summit between 1912 and 1954 are anomalous and unusually variable. For example, lava overflows from Halema‘uma‘u between 1918 and 1919 display a relatively wide range in $^{206}Pb/^{204}Pb$ (18.54-18.60) and $^{87}Sr/^{86}Sr$ (0.70347-0.70353), and anomalously high $^{207}Pb/^{204}Pb$ ratios (from a typical value of 15.50 up to 15.53). These effects likely result from the contamination of Kīlauea parental magmas with high-$^{207}Pb/^{204}Pb$ marine sediments, Fe-Mn nodules, and/or hydrothermal minerals related to the underlying Pacific oceanic crust. This assimilated component is first observed in steady-state lava lake samples from 1912, and thus, is not related to the events of 1924. Instead, mantle processes during the previous century led to decline in the magma supply rate and, for a decade prior to 1924, crustal contamination at or below the base of the volcanic edifice. Our results show that (1) changes in lava chemistry may potentially be used to predict certain types of major volcanic hazards at Kīlauea (e.g., summit collapse), and (2) mantle-driven changes in the magma supply rate may affect the crustal magmatic processes and eruptive behavior of the volcano.