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# Age and petrology of Koko Rift basalts: Hawai'i's most recent and atypical rejuvenation stage eruptive sequence

**MICHAEL O. GARCIA**[1,2], KIERSTIN SWANSON[2], CHARLINE LORMAND[3], BRIAN JICHA[4] AND MARC NORMAN[5]

[1]University of Hawai'i at Mānoa
[2]University of Hawaii at Mānoa
[3]Durham University
[4]University of Wisconsin-Madison
[5]Australian National University

Presenting Author: mogarcia@hawaii.edu

Hawai'i benefitted from Fred Frey's geochemical curiosity. Notably, his seminal 1982 paper on the Honolulu Volcanics[1] provided a foundation for this study of the Koko Rift. The 15-km long Koko Rift is Hawaii's best developed rejuvenation-stage rift. Typically, Hawaiian rejuvenated basalts have high MgO contents (>10 wt.%) and carry upper mantle xenoliths and ascended rapidly from the mantle (2). The Koko basalts are unusual in their large MgO range (5.4-12.8 wt.%) and absence of mantle xenoliths. Diffusion modeling of Fe-Mg and Ni in olivine indicates Koko magmas were stored in the crust for several months. These magmas were subsequently mixed based on reverse zoning in olivine and clinopyroxene phenocrysts. Geochemical modeling suggests three separate higher MgO magmas were mixed within the Koko Rift system. The absence of mantle xenoliths in Koko lavas and the moderate forsterite contents (84-85%) of olivine in the higher MgO lavas are additional evidence for the development of a crustal magma system within the rift. The lower MgO (5-6 wt.%) lavas were probably byproducts of a hybrid magma that underwent subsequent crystal fractionation and a second magma mixing event based on reverse zoning in their clinopyroxene and plagioclase crystals. Thus, multiple magmas within Koko system underwent months of crystal fractionation and at least two magma mixing episodes. These features make the Koko lavas unique among Hawaiian rejuvenated basalts.

Our six new $^{40}Ar/^{39}Ar$ ages cluster at 67 ± 2 ka (2s) and demonstrate that Koko is Hawai'i's youngest area of rejuvenated volcanism. The timing of Koko eruptions coincides with the ~100 m drop in global sea-level at the onset of Marine Isotope Stage 4. This major sea level fall may have triggered the Koko eruptions of magmas stored in the crust, similar to what has been proposed for eruptions for other volcanic islands[3]. The episodic nature and long duration of rejuvenated volcanism on northern Hawaiian Islands (~2 Ma), lead us to the suggest that another Honolulu eruption is possible.

[1]Clague, et al. 1982. J. Petrol. 23, 447-504. [2]Peslier et al., 2015. Geochim. Cosmochim. Acta, 154, 98-117. [3]Satow, et al., 2021. Nature Geosci. 14, 586-592

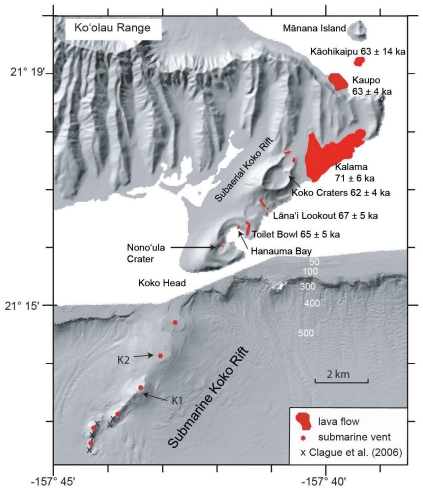


**Figure 1.** Shaded relief map of Koko Rift on the eroded SE flank of Ko'olau volcano (2-3 Ma) showing vents, lavas flows (in red) and six new $^{40}Ar/^{39}Ar$ ages. K1 and K2 indicate locations and directions of dredge hauls; basalt was recovered only on dredge haul K1. The x's along the southern submarine ridge show locations where Clague et al. (2006) collected basalt samples. The shaded relief image is from Dartnell and Gardner et al. (1999). The white numbers in the area offshore from Hanauma Bay are depths in meters.

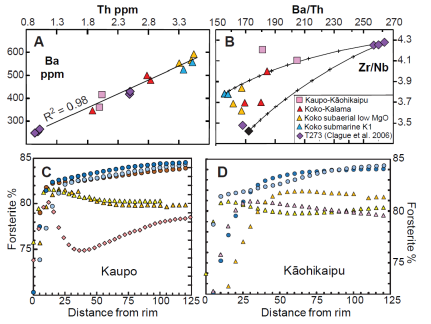


**Figure 2.** Plots of ICPMS whole-rock, trace element data for Koko Rift basalts. A. The Th vs. Ba plot of data from four Koko Rift studies shows a good linear correlation ($R^2$ = 0.98) suggesting the inter-laboratory differences are minor. B. The La/Yb vs. Th plot shows a large range in La/Yb with the southernmost submarine basalts (3 purple triangles, T273) forming one endmember and the other submarine basalts from the two other submarine cones forming other potential endmembers. The lower MgO lavas (gold triangles) have somewhat higher Th abundances that reflect crystal fractionation. Mixing curves have been modeled for panel B using the submarine basalt compositions. The pluses indicate 10% mixing increments. C and D. Compositional zoning profiles for olivine in two, higher MgO Koko Rift subaerial lavas. The higher Fo olivine (84-85%) in both flows show normal but broad zoning with a sharp drop at 10-25 microns from the rim. The olivine with lower core Fo values (78-81%) show reverse zoning towards the rim indicating magma mixing.