Sr-Nd-Pb-Hf-Mg isotope geochemistry of volcanic rocks from Oldoinyo Lengai, Tanzania

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Oldoinyo Lengai is the only active carbonatite volcano within the East African Rift Valley in northern Tanzania. The volcano is dominated by peralkaline silicate rocks with natrocarbonatites. This study presents new mineralogical and geochemical data, including Sr–Nd–Pb–Hf–Mg isotopic compositions, for volcanic rocks at Oldoinyo Lengai and lavas from the nearby Gregory Rift Valley. The samples analyzed in this study include olivine melilitite, melanephelinite, wollastonite nephelinite, and phonolite. The olivine melilitites and melanephelinites have highly fractionated REE patterns with (La/Yb)ᵣ values of 26.4–64.9, suggesting that they formed from magmas generated by low-degree (up to ~7%) of partial melting within the garnet stability field. The wollastonite nephelinites have much higher (La/Sm)ᵣ values but lower (Sm/Yb)ᵣ values relative to typical OIB, with flat HREE patterns [(La/Yb)ᵣ = ~22]. The phonolites have elevated REE abundances but with patterns intermediate between the other two sample groups [(La/Yb)ᵣ = ~41]. All samples have primitive-mantle-normalized incompatible element patterns that are characterized by negative K and Rb anomalies but no significant Eu anomalies. They also have elevated Yb contents relative to the compositions of modeled garnet peridotite-derived melts, suggesting that they were derived from a sublithospheric source containing enriched HIMU-like recycled oceanic crustal material. However, the wollastonite nephelinites have significantly positive Ba, U, Sr, and Pb anomalies similar to those found within the Oldoinyo Lengai natrocarbonatites. The wollastonite nephelinites might have been sourced from a region of sub-continental lithospheric mantle (SCLM) that was previously metasomatized by interaction with carbonate melts. The phonolites in the study area have also weakly positive Pb and Sr anomalies indicative of some interaction with the SCLM. All samples have d²⁶Mg values (~0.39‰ ± 0.07‰) lighter than the composition of normal mantle material (~0.25‰ ± 0.04‰). In addition, a negative correlation between d²⁶Mg values and MgO concentrations suggests derivation from a source region containing recycled carbonate. The samples from the study area define a mixing array between HIMU- and EM1-type OIB in Sr–Nd and Pb–Pb isotopic correlation diagrams, and have pronounced Nd–Hf isotopic decoupling, plotting below the mantle regression line in Nd–Hf isotopic space. The negative deviation from the Nd–Hf isotopic mantle array and the presence of an EM1-type mantle component in the Sr–Nd isotopic compositions of the Oldoinyo Lengai volcanic rocks can be generated by recycling of E-MORB-type oceanic crustal material with an age of 1.5–1.0 Ga.