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Isotopic constraints on the petrogenesis of the kamafugites of Uganda

K. Link (1) , A. Rosenthal (1,2) , S. F. Foley (1) , D. G. Pearson (3) , G. Nowell (3)

(1) Geosciences, University of Mainz, Mainz 55099, Germany, (2) Research School of Earth Sciences, Australian National University, Canberra, Australia, (3) Department of Geological Sciences, University of Durham, England (linkk@uni-mainz.de)

Kamafugites are a group of rare silica-undersaturated volcanic rocks originally named after three petrographically-defined rock types katungite, mafurite and ugandite from the Toro-Ankole field of southwestern Uganda, in the western branch of the East African rift valley. They correspond to strongly potassic types of olivine melilitite to nephelinite in the modern classifications. The combined low SiO_2 (31.8-41.8 wt%), high MgO (up to 22.5 wt%), low Al_2O_3 ($<$ 8.0 wt%), and high CaO contents (up to 16.6 wt%) of these volcanics express themselves in the presence of modal kalsilite, leucite, melilite and perovskite. The absence of plagioclase distinguishes them from lava flows occurring in the rest of the western rift branch. Although the compositions and petrographic characteristics of the rocks from these famous localities are used as a benchmark for strongly silica-understaurated potassic rocks all over the world, they have been little studied with modern analytical methods, particularly investigations of radiogenic isotope systems.

We have conducted a thorough geochemical study including major and trace elements, and analyses of the isotope systems Rb-Sr, Sm-Nd, Lu-Hf and Re-Os. Unlike lavas from volcanic fields further south in the western branch, the effects of crystal fractionation on the kamafugitic lavas are minor. Primitive features such as high Mg# olivines (up to 91.1), high whole-rock Mg# (up to 80.2), and high Ni (up to 1066ppm), Cr (up to 1560ppm) and Os (up to 1.45ppb) are in strong contrast to their extreme enrichment in incompatible trace elements. Sr and Nd isotopes form a cluster and are slightly enriched relative to Bulk Earth values (87Sr/86Sr = 0.704599 – 0.705402; 143Nd/144Nd = 0.512394 – 0.512575). Hf (176Hf/177Hf = 0.282508 – 0.282864) and Nd isotopes show a linear trend subparallel to, but below that of, the mantle array.

Osmium isotope ratios are superchondritic and variable (187Os/188Os = 0.14755 – 0.49735). These geochemical features can be explained by formation of kamafugitic magmas by re-melting of a variably, and episodically enriched veined lithospheric mantle characterized by highly variable supra-chondritic radiogenic Os. Impregnation of the source region by highly alkaline melts resulted in the introduction of modal phlogopite and enrichment in Fe and Re. Curved mixing lines on Hf-Nd and Sr-Os isotope plots can be explained by mixing of peridotite and pyroxenite source components, and the involvement of large amonuts of pyroxenite is also favoured by plots of Os concentrations against Ni and MgO.