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Veined pyroxenite xenoliths in Ugandan kamafugites: mantle or magma? Using in situ techniques for $^{87}\text{Sr}/^{86}\text{Sr}$ -isotopes and trace elements as tools

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The genesis of pyroxenite nodules in Ugandan kamafugites and their possible genetic relationships is a matter of debate. In earlier studies the pyroxenites were considered either as xenoliths from pervasively metasomatized peridotite mantle (Lloyd, 1981) or as distinct parageneses occurring as veins within the peridotitic mantle (Harte et al., 1993). In both cases the xenoliths would represent mantle material that was at least partly involved as source material for the kamafugite melts. A third alternative could be that they represent cumulates of the lavas. In any case, the nodules provide important information for understanding the generation of ultrapotassic lavas and for characterizing the rift-related lithosphere mantle as part of the initial continental rift process. Originally the ultrapotassic kamafugites were considered to be single stage partial melts of pervasively metasomatized mantle but new geochemical studies indicate a multistage development (Rosenthal et al., 2009). Nd, Hf and Os isotopes point to mixing between components derived from metasomatically influenced peridotite and mica-pyroxenite. In-situ investigation of the Sr-isotope and trace element compositions of individual minerals in a number of xenoliths allows us to constrain their genesis and relation to the host lavas. The nodules appear to originate by near-liquidus crystallization of melts derived from enriched peridotite within the cratonic lithosphere mantle. They later partially remelted to form one source of the potassium-rich kamafugites.

Sr-isotopes from different domains within single mineral grains in the nodules and host lavas are used to trace the nodules' role as a potential source to lavas, and trace element measurements are used to support the conclusions. Rb/Sr- measurements from the biotites to constrain the time between nodule crystallization and eruption of the Quaternary lavas to about 3.3 Ma. This also suggests a significant increase of the geothermal gradient beneath the preceding rift within that time.

Structures on microscopic scale indicate at least two different generations of mineral growth clearly related to multiphase magmatic events forming the nodules. Rare composite samples allow a correlation between the older and younger parageneses, demonstrating reaction between the older matrix pyroxenite and the younger, high-Ti melt. The relatively low ($\sim 0,13\text{wt}\%$) Cr_2O_3 -contents together with the high LREE concentrations measured in the oldest observed clinopyroxenes ($\text{La}\sim 12,4 \times \text{PRIMA}$ with $\text{La}/\text{Lu}\sim 21$) as well as the lack of any other characteristic mineral relicts argue against a pervasively overprinted peridotite mantle.

Comparable $^{87}\text{Sr}/^{86}\text{Sr}$ - values close to bulk earth values as well as similar $^{143}\text{Nd}/^{144}\text{Nd}$ - ratios in the nodules (0,512480-0,5122573) and the lavas (average: 0,512551) support a genetic link between the kamafugites and the nodules as suggested by experiments (Lloyd et al. 1985). Low radiogenic $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in Rb-free clinopyroxene and perovskite (0,704459-0,704487) constrain initial values for the source whereas slightly more radiogenic values from cogenetic Rb-bearing biotites (0,704754- 0,704762) are the result of radioactive decay after mineral growth. The majority of the kamafugite $^{87}\text{Sr}/^{86}\text{Sr}$ values lie between the two end-members (0,704624- 0,704717). Additionally considering microscale structures showing melting processes we conclude that the nodules represent one source and that the intermediate $^{87}\text{Sr}/^{86}\text{Sr}$ values of the lavas reflect the melting of differing proportions of biotite and clinopyroxene in the source region.