Synchrotron micro-XRF analysis of magmatic, carbonatitic fluorapatites: implications for the evolution of carbonatite magmas

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The general presence, abundance and crystallochemical properties of fluorapatite in carbonatites, mean that its trace element composition may be used as a geochemical indicator of magma fractionation and evolution. To test this idea, spot analyses of individual magmatic fluorapatites of six African carbonatite complexes were carried out using high-resolution synchrotron micro-XRF combined with electron microprobe analysis.

Early crystallized fluorapatites have a convex-upward rare-earth element (REE) pattern with (La/Nd)cn $\leq$ 1, and a low (La/Yb)cn ratio at a low $\sum$REE level. Fluorapatites from evolved carbonatite magmas have a straight REE pattern with (La/Nd)cn > 1, a high (La/Yb)cn mostly above 100, and an overall high $\sum$REE content. This can be explained by fluorapatite/carbonatite magma distribution coefficients with an overall positive slope from La to Yb. The highest Y/Ho ratios (up to 70) are observed in early fluorapatites while late fluorapatites have an Y/Ho ratio below the chondritic value of 28. There is a distinct tendency to develop a negative Eu-anomaly from early to late fluorapatites. Also, the Th and Sr contents, and the Th/U ratios tend to increase from early to late fluorapatites. We suggest that REE and trace element signatures of magmatic fluorapatites may be indicative of the relative stage of fluorapatite crystallization in carbonatitic magmas.