Are carbonate-fluorapatite rocks in carbonatite complexes the result of hydrothermal processes or weathering?

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Carbonate-fluorapatite (also known as staffelite and/or francolite) can become a rock-forming mineral in the upper levels of some carbonatite complexes, such as at Sokli, Finland, and Kovdor, Russia. Carbonate-fluorapatite rocks are recognised as an important phosphate resource, but there is little consensus on their genesis. Two principal models are favoured: (1) a hydrothermal origin, from a late-stage, carbonatite-derived fluid or, (2) formation through supergene dissolution of carbonate and re-precipitation of apatite.

In this contribution, we have investigated the texture and composition of different carbonate-fluorapatite generations (using cathodoluminescence microsopy and LA ICP MS) in order to evaluate the aforementioned formation mechanisms. Four carbonate-fluorapatite growth generations were identified: (1) primary apatite grains, with a rounded/euhedral habit and luminescing purple; (2) strongly luminescent epitactic rims on primary grains; (3) 'aggregate' apatite, forming a fine-grained groundmass, typically luminescing blue; (4) botryoidal growth zones, commonly luminescing blue, but in places green or non-luminescent. REE contents in secondary carbonate-fluorapatite generations (2–4) are markedly low, with some analyses below detection limit (typically <1 ppm). Furthermore, many of these analyses exhibit both positive and negative Ce anomalies, indicative of an oxidising environment.

The low REE contents of the different carbonate-fluorapatite generations indicates that negligible REE transfer occurred between different growth events, contrasting with hydrothermal apatite in other carbonatite complexes. Furthermore, the lack of any significant fractionation between subsequent carbonate-fluorapatite generations is interpreted as circumstantial evidence that these rocks did not form through hydrothermal alteration. This is compounded by the presence of a Ce anomaly, which is commonly interpreted as a weathering feature. While hydrothermal formation under different conditions, causing complete removal of the REE, cannot be ruled out, we conclude that the locations were, most-likely, formed in a supergene environment. Continued investigation of weathered carbonate-fluorapatite material from other localities is underway to assess this conclusion.