



## **Thorium in the pyrochlores of continental and oceanic carbonatites**

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Pyrochlore is a typical accessory rare metal mineral of continental and oceanic carbonatites of diverse composition: sovites, befor sites etc. Early continental carbonatites are usually calcite-rich and have elevated contents of rare elements. This is due to the pervasive development of minerals belonging to the pyrochlore group enriched in U and Th. U-Th pyrochlores are present in the carbonatites of the Kola alkaline province (KAP) - Vuoriyarvi, Kovdor, Seblyavr, Sokli. They are also found in Priazovie, Ukraine, in calcitic carbonate veins of the Khlebodarovka deposit. Oceanic calcitic carbonatites from Cape Verde Archipelago (Fogo island) are also characterized by the elevated contents of rare elements. Among the rare metal minerals there are sequentially formed zirconolite, zircon, pyrochlore-group minerals, Nb-Zr-Ti-Si phases and thorite. The enrichment of pyrochlores of oceanic carbonatites in radioactive elements is their geochemical and typomorphic feature.

Usually radioactive elements in carbonatites are present together in early rare metal minerals and they are microcomponents. Continental carbonatites are characterized by the predominance of U over Th. The distribution of rare and radioactive within the crystals is zoned. In the early types of carbonatites from KAP the major concentrator of Th is uranopyrochlore. The distribution of Th within crystals is inhomogeneous, patchy. The overgrown rim is usually thin and enriched in Ba and Sr. The maximal contents of ThO<sub>2</sub> in uranopyrochlore from the massifs of the Kola alkaline province are as follows - Vuoriyarvi – 11.24 wt%, Kovdor – 11.19 wt%, Sokli – 14.59 wt%. The distribution of Th in pyrochlore from Khlebodarovka is also zoned. The rhythmic growth zoning is observed with the enrichment of cores in ThO<sub>2</sub> up to 9.86 wt%. There are also crystals with the patchy zoning which is due to the recrystallisation of the early Th-rich pyrochlore.

In the rare metal minerals of oceanic carbonatites Th prevails over U. The average content of ThO<sub>2</sub> in zirconolites is 2-5 wt %, UO<sub>2</sub> is less than 2 wt %. The distribution of Th in rare metal minerals is zoned, the rims of crystals are depleted in this element. The content ThO<sub>2</sub> in the central parts of zircons may reach 4 wt%, whereas marginal parts practically do not contain ThO<sub>2</sub>. Among the minerals of pyrochlore group with the maximal Th content in A-position (up to 18 wt% ThO<sub>2</sub>) is a separate mineral species – “thoriopyrochlore”. On the correlation diagrams oceanic “thoriopyrochlores” occupies definite position and creates separate field. From the interrelationships of cations occupying B-site they differ from pyrochlores continental carbonatites in elevated Ti contents and lower contents of Nb, they are enriched in Th, U, REE.

Thus, in the rare metal minerals of oceanic carbonatites Th prevails over U, Th is accumulated in the final products of the transformation of the early rare metal phases – “thoriopyrochlore”. In the pyrochlore of continental carbonatites Th is a subordinate trace-element and does not form separate minerals. In the late carbonates of hydrothermal origin Th is almost completely disseminated, and its content in the rare metal minerals is negligible.