

## **Occurrence and chemistry of pyrochlore and baddeleyite in the Sokli carbonatite complex, Kola Peninsula, Arctic**

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The chemical compositions and textural relationships of the Nb-Zr oxide minerals including pyrochlore [ideally  $(Ca,Na)_2Nb_2O_6(OH,F)$ , with up to 24%  $UO_2$  and 16%  $Ta_2O_5$ ] and baddeleyite [ideally  $ZrO_2$ , with up to 6%  $Nb_2O_5$ ] in the Sokli carbonatite complex, Kola Peninsula, Arctic are described. These two minerals in carbonatites are the major hosts for the HFSEs such as U, Th, Ta, Nb, Zr and Hf and thus are interest both economically and petrologically.

The Sokli carbonatite complex (360-370 Ma) in Northern Finland, which forms a part of the Paleozoic Kola Alkaline Province (KAP), is mainly composed of multi-stages of carbonatite and phoscorite associations (P1-C1, P2-C2, P3-C3, D4 and D5) surrounded by altered ultramafic rocks (olivinite and pyroxenite) and cut by numerous small dikes of ultramafic lamprophyre. The Sokli complex contains the highest concentration in niobium and probably in tantalum, which are economically very important to modern steel technology, among the ultramafic-alkaline complexes of the KAP.

Pyrochlore and baddeleyite mostly concentrate in the phoscorites. Pyrochlores in the Sokli complex are generally rounded octahedra and cubes in shape, red brown to grey yellow in color, and 0.2 to 5 mm in size. They are found in all calcite carbonatites, phoscorites and dolomite carbonatites, except P1-C1 rocks. These pyrochlores display remarkable zonations which depend on host rock compositions, and have significant compositional variations with evolution of the Sokli complex. The common variation scheme is that (1) early pyrochlore is highly enriched in U and Ta; (2) these elements decrease abruptly in the intermediate stage, while Th and Ce increase, and (3) late stage pyrochlore is low in U, Ta, Th, and Ce, and correspondingly high in Nb.

Baddeleyites in the Sokli complex occur in the early P1-C1 and P2-C2 rocks and rarely in P3. They crystallized earlier than pyrochlores, and occasionally show post-magmatic corrosion and replacement. The FeO and  $TiO_2$  contents of baddeleyites are much lower than those of the other terrestrial and lunar baddeleyites, whereas  $Nb_2O_5$  and  $Ta_2O_5$  contents are the highest among the reported compositions.

Ta/Nb and Zr/Nb ratios of pyrochlores and baddeleyites decrease towards later stage facies, which is in accordance with the whole rock compositions. The variation of Ta/Nb and Zr/Nb ratios of pyrochlores and baddeleyites is considered to be a good indicator to trace an evolution of the carbonatite complexes.