REE and Nb in minerals from rocks of the Belaya Zima carbonatite complex, Russia

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The Belaya Zima Nb and REE deposit in Eastern Sayan, Russia, is hosted by calcite, calcite-dolomite and ankerite carbonatites emplaced in a juncture zone of folds and the Siberian platform in Neoproterozoic.

The concentration of Nb in early calcite carbonatites is up to 15700 ppm. The main primary Nb mineral here is pyrochlore (including the U-pyrochlore variety). The Nb enrichment is also reflected by the presence of accessory fersmite, baotite, zirconolite and others. Columbite-(Fe) developed as a replacement product after pyrochlore at a late stage of the carbonatite evolution (ankerite carbonatites). Alkaline silicate rocks (melteigites, ijolites, syenites) associated with the carbonatites are barren in Nb (up to 620 ppm); the bulk of Nb in these rocks is contained in perovskite, garnet, and, to a much lesser extent pyroxene, amphibole and magnetite. Contents of REEs in the early calcite carbonatites are up to 2600 ppm. REEs are distributed among apatite, calcite, pyrochlore, accessory ancylite-(Ce), burbankite, zirconolite. Late ankerite carbonatites are strongly enriched in REE (in average 3.5-5 wt. %) with major REE-minerals such as Ca-fluocarbonates, monazite-(Ce), rhabdophane-(Ce). These minerals precipitated later than LREE-bearing ankerite and dolomite. The REE contents in the associated alkaline rocks is low compared to that of the carbonatites (up to 0.2 wt. %). The REEs are mainly hosted by perovskite, apatite, titanite, garnet and pyroxene. Increasing $(La/Yb)_{CN}$ in minerals from carbonatites and alkaline silicate rocks during their evolution and variations in key element ratios, such as Nb/Ta and Zr/Hf as well as chondrite-normalized profiles of the REE- and Nb- bearing minerals record multistage processes of fractional crystallization from primary melts and subsequent hydrothermal stages.

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