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Formation of REE-rich carbonatites from the Petyayan-Vara area (Vuoriyarvi Massif, NW Russia)

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We present a consistent model for the formation of REE-rich carbonatites from the Petyayan-Vara area (Vuoriyarvi Massif, NW Russia) based on geological, mineralogical, geochemical, fluid inclusion, and Sm-Nd-C-O isotopic data.

At the magmatic stage (field A in Fig), Ba-Sr-REE-enriched Mg-carbonatitic melt with isotopic characteristics of the depleted mantle was injected into silicate rocks of the Vuoriyarvi massif, which led to the formation of primary burbankite-bearing magnesiocarbonatites. (2) Contact interaction of carbonatitic melt with silicate rocks triggered the formation of high-Ti carbonatites with a mantle $\delta^{13}C_{PDB}$ (ca. –4 ‰) and an isotopically heavy $\delta^{18}O_{SMOW}$ (ca. 20 ‰). These rocks trapped K, Na, Mg, CO_2, and REEs (mainly HREEs) from the melt and Si, Al, Fe, Ti, and P from the host rocks. The additional input of Ti, Nb, and P from crustal fluid caused the generation of (3a) brookite, pyrochlore, and (3b) apatite (w/o REEs) mineralization in high-Ti carbonatites and adjacent primary magnesiocarbonatites.

During the early post-magmatic stage (field B in Fig), primary magnesiocarbonatites (4) at T° > 350 °C were exposed to a concentrated S-rich carbonatitic fluid, which dissolved burbankite and accumulated Ba, Sr, and REEs. The remobilized elements were sequentially deposited. As a result, (5) baryte-rich and (6) ancylite-rich magnesiocarbonatites, as well as (7) giant-grained calciocarbonatites, were formed. The impact of this fluid on apatite (8) caused its epitaxial overgrowth by an REE-S-rich apatite. In all the listed rocks, the Sm-Nd system has remained closed since the formation of the complex. This indicates a short-time-interval between the magma embedding and early post-magmatic processes.

Late overprint of carbonatites (field C in Fig) occurred before exhumation of the complex and is associated with a crustal low-salinity hydrocarbon-chloride fluid acted at T° > 150 °C. The effect of this fluid yielded (9) decomposition of apatite and deposition of monazite, (10) crystallization of the quartz+bastnaesite assemblage at the expense of ancylite, and (11) formation of strontianite-rich carbonatites. The crustal fluid restructured all studied isotope systems and increased the radiogenic strontium.

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