First experimental evidence for magmatic crystallization of bastnaesite and burbankite

ANNA NIKOLENKO, PHD1,2,3, KONSTANTIN STEPANOV3 AND ILYA V. VEKSLER3,4
1Helmholtz Centre Potsdam – German Research Centre for Geosciences GFZ
2Potsdam University
3V.S. Sobolev Institute of Geology and Mineralogy SB RAS
4GFZ German Research Centre for Geosciences
Presenting Author: nikolenko@uni-potsdam.de

Bastnaesite [REE(CO3)F] is the main mineral of rare earth ore deposits in carbonatites. Synthetic analogues of bastnaesite have been precipitated from aqueous solutions by many different methods. However, previous attempts to model magmatic crystallization of bastnaesite in the system La(OH)3 – Ca(OH)2 - CaCO3 (Jones and Wyllie, 1986) were unsuccessful. Here we present the first experimental evidence for magmatic crystallization of bastnaesite and some other REE carbonates in the model system La(CO3)F – CaCO3 – Na2CO3 at 100 MPa and temperatures between 625 and 850 °C.

Our experiments on mixtures of reagent-grade CaCO3, Na2CO3, La2(CO3)3 and LaF3 were carried out in cold-seal rapid-quench pressure vessels. Positions of the starting compositions on T-x phase diagram (see the figure) are shown by grey circles. Carbon dioxide and fluorine were found to behave as independent components and, therefore, the system is pseudoternary. The liquidus phases are calcite (Cc), nyrereite (Nye), natrite (Nc), bastnaesite (Bst) and burbankite solid solution (Bur). Sodium-lanthanum fluorcarbonate analogous to ariste appeared in one run in sub-liquidus at 625 °C. Calcite, bastnaesite and burbankite solid solution (Na,Ca)3(Ca,La)3(CO3)5 are involved in a peritectic reaction which corresponds to the piercing point P1 on the liquidus surface. There are at least two other piercing points (P2) and (P3) which are probably pseudo-eutectics (local temperature minima).

The solubility of La2O3 in melts saturated in calcite and bastnaesite decreases from 44 to 20 wt.% with falling temperature and in parallel with increasing Na/Ca in the evolving liquid. The solubility is so high that it is hardly reachable by REE in natural carbonatite magmas. In nature, the REE solubility is probably controlled by phosphates (apatite and monazite) and Nb-Ti minerals of the perovskite and pyrochlore groups. Thus, despite the stability of bastnaesite and burbankite in the model system, it remains unclear whether they can crystallize in carbonatites as primary magmatic minerals. Answering this question would require experiments on compositions containing P2O5 and TiO2 that we are planning in the future.

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References