Experimental study of Th-bearing LaPO$_4$ (780 °C, 200 MPa): Implications for monazite and actinide orthophosphate stability

Renaud Podor and Michel Cuney

Center de Recherches sur la Geologic des Matiéres Premiéres Minerales et Energétiques, Groupement de Recherches between CNRS and CREGU, no. 77, B. P. 23, 54501 Vandœuvre-Les-Nancy Cedex, France

Abstract

A complete solid solution has been hydrothermally synthesized between the two end-members LaPO$_4$ and (Ca$_{0.5}$Th$_{0.5}$)PO$_4$ at 780 °C and 200 MPa, indicating that there is no limitation in temperature and pressure conditions corresponding to those of granitic magmas for Th insertion in natural monazites. The composition limits of the (A$^{3+}_{1-2x}$ B$^{2+}_x$ C$^{4+}_x$)PO$_4$ compounds crystallized in the monazite structure-type are determined by both $r_{average} = (1 - 2x)\ ^{[9]}r_{A^{3+}} + x\ ^{[9]}r_{B^{2+}} + x\ ^{[9]}r_{C^{4+}}$ and $r_{ratio} = (1 - x)^{[9]}r_{A^{3+}} + x^{[9]}r_{B^{2+}}/(1 - x)\ ^{[9]}r_{A^{3+}} + x^{[9]}r_{C^{4+}}$ parameters (where $^{[9]}r_A$ is the ionic radius of the A element in ninefold coordination). The upper and lower values of these parameters are 1.216 Å $\geq r_{average} \geq$ 1.107 Å and 1.238 $\geq r_{ratio} \geq$ 1. The incorporation of large amounts of trans-uranium elements in the monazite structure is deduced from this model. The limitations and geochronological inferences of this model are discussed.