

Monazite-xenotime thermobarometry: Experimental calibration of the miscibility gap in the binary system $\text{CePO}_4\text{-YPO}_4$

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ABSTRACT

Solid solutions of $(\text{Ce,Y})\text{PO}_4$ were synthesized hydrothermally between 300 °C and 1000 °C at pressures of 2, 5, 10, and 15 kbar. Experiment products were analyzed by electron microprobe, and their lattice parameters were refined by Rietveld analysis of XRD powder patterns. Over a wide range of bulk compositions, two immiscible phases formed: monazite with a $P2_1/n$ structure (REEO_9 polyhedron) and xenotime with an $I4_1/amd$ structure (REEO_8 polyhedron). Variations of the unit-cell dimensions are directly correlated with variations in composition. The boundaries of the asymmetric miscibility gap are strongly dependent on temperature. At 2 kbar and from 300–1000 °C, maximum Y concentrations in monazite coexisting with xenotime increase from 3–16 mol%. With increasing pressure, this limb is shifted to higher Y contents so that at 15 kbar it ranges from 6 to about 25 mol% for the same temperature range. In contrast, Ce concentrations in xenotime do not exceed 3 mol% at 1000 °C over the entire pressure range. Our experimentally determined boundaries fit surprisingly well with empirical calibrations of the $(\text{LREE-HREE,Y})\text{PO}_4$ -solvus boundaries derived from a suite of low pressure metapelites (3 to 5 kbar) that equilibrated at peak temperatures ranging from 400–700 °C. The behavior of the natural $(\text{REE,Y})\text{PO}_4$ system is probably well described by the simple $(\text{Ce,Y})\text{PO}_4$ binary, at least for metapelitic compositions. Many natural samples of monazite coexisting with xenotime show prograde growth zonation with respect to the incorporation of HREE + Y. The combination of our thermometer along with U-Pb and Sm-Nd age determinations of high spatial resolution may thus provide information about prograde branches of metamorphic PTt paths.