

Experimental determination of stability relations between monazite, fluorapatite, allanite, and REE-epidote as a function of pressure, temperature, and fluid composition

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ABSTRACT

The experimental alteration of monazite to allanite, REE-epidote, fluorapatite, and/or fluorapatite-britholite was investigated at 450 to 610 MPa and 450 to 500 °C. Experiments involved monazite + albite ± K-feldspar + muscovite ± biotite + SiO₂ + CaF₂ and variety of fluids including H₂O, (KCl + H₂O), (NaCl + H₂O), (CaCl₂ + H₂O), (Na₂Si₂O₅ + H₂O), 1 M HCl, 2 M NaOH, 2 M KOH, 1 M Ca(OH)₂, 2 M Ca(OH)₂, and (CaCO₃ + H₂O). The reaction products, or lack thereof, clearly show that the stability relations between monazite, fluorapatite, and allanite or REE-epidote are more dependent on the fluid composition and the ratio of silicate minerals than on the *P-T* conditions. A high Ca content in the fluid promotes monazite dissolution and the formation of fluorapatite and allanite or REE-epidote. Lowering the Ca content and raising the Na content in the fluid decreases the solubility of monazite but promotes the formation of allanite. Replacing Na with K in the same fluid causes fluorapatite, with a britholite component, to form from the monazite. However, allanite and REE-epidote are not formed. Monazite is stable in the presence of NaCl brines. In KCl brine, monazite shows a very limited reaction to fluorapatite. When the fluid is (Na₂Si₂O₅ + H₂O), strong dissolution of monazite occurs resulting in the mobilization of REEs, and actinides to form fluorapatite-britholite and turkestanite. These experimental results are consistent with natural observations of the partial to total replacement of monazite by fluorapatite, REE-epidote, and allanite in fluid-aided reactions involving the anorthite component in plagioclase at mid- to high-grade metamorphic conditions. In contrast, an alkali-bearing environment with excess Na prevents the growth of allanite and eventually promotes the precipitation of secondary monazite. The results from this study provide implications for geochronology and for deducing fluid compositions in metamorphic rocks.

Keywords: Monazite, fluorapatite, allanite, REE-epidote, experimental petrology