

Experimental Nucleation of Co-Existing Monazite and Xenotime Grains in Chlorapatite

Daniel Harlov (dharlov@gfz-potsdam.de) & Förster Hans-Jürgen (forhj@gfz-potsdam.de)

GeoForschungsZentrum, Telegrafenberg, Potsdam, F.R. Germany

The REE geochemistry of metamorphic rocks is influenced principally by the composition of apatite, monazite, and xenotime. However, the genetic and crystallochemical relationships between these three phosphate minerals are not well understood (Pan et al., 1993). For example, in nearly pure chlor-apatites (1-2 wt% Y+REE) in a pegmatoid from the Ødegårdens Verk, Bamble Sector, SE Norway (Leiftink et al. 1994), numerous monazite and xenotime grains are observed in areas where the chlor-apatite was metasomatically altered to Cl-OH-rich fluor-apatite under amphibolite facies conditions (700 °C; 0.5 -0.6 GPa). In contrast, regions of the chlor-apatite in the same crystal which were not metasomatised do not contain monazite or xenotime inclusions. In order to determine the source of these inclusions as well as what role high grade fluids (and their specific composition) may have played in inducing their formation, two types of experiments were performed in the piston cylinder (900 °C; 1 GPa; one week duration). A non-metasomatised sample of this chlor-apatite was first crushed into 50-200 mm size grains. In the first experiment (Exp I), chlor-apatite (20 mg) and H₂O (5 mg) were placed in a Pt capsule and the capsule welded shut. In the second (Exp II), a 50/50 molar H₂O/F fluid (6 mg) was used with CaF₂ as the source for F. In Exp I, numerous co-existing monazite and xenotime grains volunteered in regions showing both depletion in Y+REE, Na, Si, and Cl as well as enrichment in OH, F, Ca, and P. In the Exp II, no monazite or xenotime grains precipitated. The chlor-apatite was depleted in Cl and Na but

enriched in F and Si, with the silica most likely coming from some very minor natural quartz associated with the Cl-apatite. The Y+REE content remained approximately constant. These results suggest that in either experiment the following exchange vectors $\text{Na}^+ + (\text{Y+REE})^{3+} = 2 \text{Ca}^{2+}$ and $\text{Si}^{4+} + (\text{Y+REE})^{3+} = \text{P}^{5+} + \text{Ca}^{2+}$ were prevalent. In Exp I, as Na and Si migrated out from the Cl-apatite into the fluid, a charge imbalance was created and the Y+REE nucleated monazite and xenotime grains within the body of the apatite grain. In Exp II, while Na migrated out into the fluid, trace amounts of Si, possibly complexed with F, migrated into the apatite structure, thereby stabilizing the Y+REE such that no monazite or xenotime inclusions formed. The same two experiments performed in the hydrothermal apparatus at 600 °C; 0.5 GPa; and 2-3 weeks duration gave the same results. By analogy, the results of this study imply that monazite inclusions observed in fluor-apatite from granulite facies rocks (cf. Förster and Harlov, 1999) most likely nucleate from the Y+REE budget available within the apatite and that these inclusions are a product of the above exchange vectors in conjunction with high grade fluids which serve as a means for Na and/or Si mobility in the rock.

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