Hydrothermal mineral replacement reactions for an apatite-monazite assemblage in alkali-rich fluids

W. B. BETKOWSKI[1]*, D. HARLOV[2] AND J. RAKOVAN[1]

[1]Miami University, Department of Geology and Environmental Earth Science, 114 Shideler Hall, Oxford, OH 45056 (betkowwb@miamioh.edu)

[2]GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany

Mineral replacement reactions are very common in the geological world. One specific class of replacement reactions occurs via a fluid-aided, spatially and temporarily coupled dissolution and precipitation mechanism. Such reactions manifest themselves in numerous possible replacement textures and are commonly found in hydrothermal systems.

In order to test several hypotheses for well-established geochronologic inconsistencies between apatite and monazite radiometric ages from a hydrothermally altered tin deposit in Llallagua, Bolivia, a series of monazite and fluorapatite replacement experiments have been performed. Fluid-mineral experiments were conducted utilizing hydrothermal line autoclaves in a temperature range from 300 C° to 600 C°, at 100 MPa pressure in an alkali-rich fluid environment (H_2O + $Na_2Si_2O_5$).

Experimental results were evaluated using a scanning electron microscope (SEM) and electron microprobe analysis (EMPA) on selected areas of the reaction products. Exclusively, during the 500 C° and 600 C° runs, zoned fluorapatite rim replacement textures formed with sharp, non-diffusive reaction fronts, suggesting a dissolution-precipitation mechanism. Altered areas are significantly enriched in Na+(Y+REE) and/or Si+(Y+REE) via the coupled substitution reactions Na + (Y+REE) = 2Ca and Si + (Y+REE) = Ca + P. In the same experiments monazite was extensively altered. This was often accompanied with the formation of a symplectite texture. The symplectites are significantly enriched in Si and (Y+REE) and seem to indicate a crucial role for Si-(Y+REE) complexes during chemical mass transfer. Lower temperature experiments showed that monazite was also partially replaced to a lesser extent, but without symplectite formation. Simultaneously, apatite experienced limited dissolution, and no rim replacement textures or depletion areas were formed.

Results indicate that low temperature selective replacement of monazite in a monazite and apatite vein assemblage can occur. This is consistent with the hypothesis that selective mineral replacement reactions are the source of the observed geochronologic discrepancies at Llallagua.