An experimental study of apatite metasomatized by S-bearing fluid: the element redistribution and the formation of monazite and anhydrite

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Coupled dissolution – reprecipitation processes in apatite during metasomatism can occur both in nature as well as experimentally [1, 2, 3]. Various fluids can affect the growth of monazite and/or xenotime as well as element redistribution in apatite. We have conducted a series of hydrothermal experiments on the dissolution of fluorapatite in reactions with sulfate-bearing and saline fluids at post-magmatic P-T conditions. The fluorapatite used in these experiments are inclusion-free grains (size 0.5 - 1 mm) extracted from magnetite-apatite rocks of the Mushgai-Khudag complex (South Mongolia). The fluids used include aqueous solutions of H₂SO₄ + La₂(SO₄)₃, FeCl₃ and H₂SO₄ + Fe₂O₃ (La₂SO₄ or FeCl₃/H₂O = 50/50, La₂SO₄ or Fe₂O₃/1N H₂SO₄ = 50/50). The solids + fluids were placed in 1 cm long/3mm wide Pt capsules and arc-welded shut. They were then placed in a cold-seal autoclave on a hydrothermal line at 200 MPa and 600 °C for a duration of about 3 weeks. The experiments were quenched using compressed air and the products were analyzed by SEM and EMP.

In the La₂(SO₄)₃/H₂O experiments, the fluorapatite did not show any changes in composition compared to the original fluorapatite. Monazite and anhydrite did not form. In the La₂(SO₄)₃/H₂SO₄ experiments, monazite and cubic crystals of anhydrite were formed along the cracks and rims of the fluorapatite grains. A single grain of fluorite was found associated with anhydrite and monazite. Fluorapatite metasomatized in a FeCl₃/H₂O saline solution developed light trails across the grain surface. These trails are moderately depleted in Ca, P, Sr, and enriched in Si, S, and LREE as compared with the darker areas, which represent the original fluorapatite. Monazite and anhydrite did not form. In the Fe₂O₃/1N H₂SO₄ experiments, the fluorapatite developed a zonal structure where light zones are enriched in Si and LREE. Cubic crystals of anhydrite formed along the cracks and rims of the fluorapatite grains. Monazite did not form. A Fe-Ca-P phase was found as rounded or elongated grains within the fluorapatite.

Our results indicate that H₂SO₄ in the fluid promotes the highest reactivity allowing for the formation of new mineral phases in the fluorapatite during the dissolution-reprecipitation process.

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