

Reactions of strontium anorthite with H₂O+CaCl₂ fluids at 500 °C and high pressure: Kinetic information from in situ synchrotron-radiation XRF analyses of the fluid

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ABSTRACT

The assemblage strontium anorthite, quartz, and kyanite was reacted with H₂O+CaCl₂ solutions at 500 °C and pressures between 460 and ~1300 MPa using a hydrothermal diamond-anvil cell. Information on the kinetics was obtained in situ based on time-resolved synchrotron-radiation X-ray fluorescence analyses of the Sr concentration in the fluid. The reaction products (anorthite or zoisite) were studied using transmission electron microscopy to obtain information on the reaction mechanism and mineral-fluid partitioning of strontium. The time required for equilibration was primarily controlled by the reaction mechanism, but not discernibly affected by pressure or chloride concentration. Nucleation and growth of zoisite at the expense of strontium anorthite was much faster than the Sr-Ca exchange reaction of strontium anorthite to anorthite, and resulted in chemically homogeneous crystals. The anorthite had developed a high nanoporosity during the reaction, which is indicative of coupled dissolution-precipitation. A zoisite-fluid exchange coefficient

$$K_{D(\text{Sr-Ca})}^{\text{zoisite-fluid}} = \frac{X_{\text{Sr}}^{\text{zoisite}}}{X_{\text{Ca}}^{\text{zoisite}}} / \frac{X_{\text{Sr}}^{\text{fluid}}}{X_{\text{Ca}}^{\text{fluid}}} = 0.42$$

was obtained for the Sr-Ca fractionation at 500 °C and ~1300 MPa. At low bulk Sr/Ca, this value is in very good agreement with literature data, which are based on zoisite syntheses from oxide and hydroxide mixtures in chloridic fluids at 600 °C, 2 GPa and analyses after quench. This suggests that the Ca-Sr ratios in fluid and zoisite were not affected by back reactions during quenching. The constrained anorthite-fluid Sr partition coefficient for 500 °C, 460 MPa is, likewise, consistent with literature data, but determination of mineral-fluid partition and exchange coefficients can be hampered by quench phases in nanopores if coupled dissolution-precipitation acted as reaction mechanism.

Keywords: Strontium anorthite, zoisite, aqueous fluid, kinetics, mineral-fluid partitioning, in situ SR-XRF analysis, electron microscopy, Raman spectroscopy