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Ca-Sr distribution among amphibole, clinopyroxene, and chloride-bearing solutions

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ABSTRACT

The distribution of Sr between a 1 *M* $(Ca,Sr)Cl_2$ solution, (Ca,Sr)-tremolite and (Ca,Sr)-diopside was determined at 750 °C and 200 MPa. The synthesized crystals of (Ca,Sr)-tremolite (2000 × 30 μm) and (Ca,Sr)-diopside (1500 × 20 μm) were large enough for accurate electron microprobe analysis. The experimental results indicate that Ca^{2+} can be replaced completely by Sr^{2+} on the M4-site in tremolite and on the M2-site in diopside. The compositions of the product fluid were analyzed by atomic absorption spectroscopy. In both the (Ca,Sr)-tremolite-fluid and (Ca,Sr)-diopside-fluid systems, Sr strongly fractionated into the fluid. For bulk compositions having low Sr concentrations, mineral/fluid partition coefficients, $D_{Sr}^{mineral/fluid}$, of 0.045 for (Ca,Sr)-tremolite/fluid and 0.082 for (Ca,Sr)-diopside/fluid were derived. The experimental results were evaluated thermodynamically assuming Henry's law and simple mixing properties for $SrCl_2$ and $CaCl_2$ in the fluid. The mixing energies of the solids were calculated using a regular solution model. In the (Ca,Sr)-tremolite–$(Ca,Sr)Cl_2$ system, $\Delta\mu°$ is 59.0 kJ and W_{CaSr}^{amph} = 9.8 kJ. In the system (Ca,Sr)-diopside–$(Ca,Sr)Cl_2$ $\Delta\mu°$ is 30.8 kJ and W_{CaSr}^{px} is 11.7 kJ. The high $\Delta\mu°$ values and, to a much lesser extent, the W_{CaSr} values cause the strong fractionation of Sr into the fluid. The moderate values for W_{CaSr}^{amph} and W_{CaSr}^{px} strongly suggest that complete solid solution exists for (Ca,Sr)-tremolite and (Ca,Sr)-diopside at experimental run conditions. However, for the (Ca,Sr)-tremolite and (Ca,Sr)-diopside joins, limited miscibilities were calculated below 316 and 430 °C, respectively.

The experimentally derived thermodynamic properties were used to determine Ca/Sr ratios of Sr-rich metasomatic fluids that penetrated a metaeclogite in Bjørkedalen, southwest Norway. The derived Ca/Sr ratios from amphibole-fluid equilibria are in good agreement with those calculated from plagioclase-fluid equilibria.