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Experimental and infrared characterization of the miscibility gap along the tremolite-glaucophane join

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Abstract

Knowledge of the thermodynamic mixing properties of amphiboles whose compositions lie along the tremolite-glaucophane join is of interest to those studying high-pressure metamorphic rocks as well as rocks transitional between the greenschist and blueschist facies. This study is the second of a two-part investigation of the tremolite-glaucophane join, with the first study (Jenkins et al. 2013) devoted to the volume composition and crystal chemical relations, and the current study focused on defining the location and extent of asymmetry of the miscibility gap (solvus) along this join. A series of experiments was done over the temperature range of 500–800 °C at pressures of 1.6–1.9 GPa to determine the location of the miscibility gap using both two-amphibole dissolution experiments, including time-series experiments at 700, 750, and 800 °C lasting up to 670 h, as well as various end-member and intermediate amphibole overgrowth techniques to approach the boundary from different compositional directions. These results, which placed some important limits on the location of the miscibility gap, were combined with an autocorrelation analysis of the mid- and far-infrared spectra of single-phase amphiboles formed in the first study (Jenkins et al. 2013) to refine the shape of the miscibility gap. Derived values of the relative change in the autocorrelation parameter ($\delta\Delta Corr$) were fairly constant over all of the frequency ranges analyzed and indicated that the miscibility gap is steeper at the glaucophane-rich compared to tremolite-rich side of the binary join. Combining the compositional re-equilibration experiments with the infrared autocorrelation results permitted deriving the ratio of the parameters $\alpha_{Gl}/\alpha_{Tr} = 0.5$ and $W_{TrGl} = 67–70$ kJ using asymmetric formalism theory. The calculated boundary has a critical-point temperature that falls in the range of 760–800 °C in this iron-free system. The asymmetry of the calculated miscibility gap appears to be confirmed by amphibole pairs in nature. The implications of this study are that this technique of combining compositional re-equilibration experiments with autocorrelation analysis of single-phase solid solutions is a potentially powerful method of locating miscibility gaps at low temperatures and for chemically complex binary joins. It is also suggested that the miscibility gaps presented here provide a basis for interpreting the degree of equilibrium reached in assemblages with complexly zoned or intergrown amphiboles.

Keywords: Glaucophane, tremolite, miscibility gap, autocorrelation analysis, FTIR