

## The stability of tremolite: New experimental data and a thermodynamic assessment

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### ABSTRACT

The equilibria:



have been reversed experimentally at  $P_{\text{fluid}} = P_{\text{H}_2\text{O}} = 0.5$  kbar, 1.0 kbar, and 5.0 kbar and at  $P_{\text{fluid}} = P_{\text{H}_2\text{O}} + P_{\text{CO}_2} = 5$  kbar, respectively. Starting materials consisted of natural tremolite (St. Gotthard, Switzerland) and quartz (Brazil), and synthetic calcite, forsterite, diopside, and enstatite mixed in stoichiometric proportions. Reaction direction was determined by comparing XRD patterns of reactant and product assemblages and by examining surface features of experimental products with an SEM.

Our new experimental data for Equilibrium 1 are consistent with the natural-tremolite results of Skippen and McKinstry (1985), who used St. Gotthard tremolite, whereas the new bracket for Equilibrium 4 is  $\approx 25$  °C lower than that of Slaughter et al. (1975) who also used St. Gotthard tremolite. Comparison of our results with other studies indicates that use of the St. Gotthard tremolite in place of synthetic tremolite in the starting material displaces these equilibria toward higher temperatures by about 25 and 5 °C, respectively. Tremolite stability differences reflected in these data, as well as in phase equilibrium data for nine additional equilibria involving synthetic and natural tremolite can be accounted for with a simple ideal on-site mixing model to describe tremolite compositional differences. Our analysis leads us to conclude, however, that tremolite growth in some experiments near the equilibrium boundary occurs with respect to metastable end-member pyroxenes used in starting materials, whereas pyroxene-stable half-brackets involve growth of stable pyroxene compositions. Thermodynamic properties for end-member tremolite, retrieved by mathematical programming analysis of the experimental phase equilibrium data with these assumptions, provide the most sound basis for prediction of calcic amphibole stability relationships in natural assemblages, as well as improved calibration of quantitative amphibole geothermobarometers. Our success in extracting consistent thermodynamic properties for end-member tremolite from experimental data obtained with both synthetic and natural tremolite, assuming the former to contain 10 mol% magnesio-cummingtonite component (Jenkins 1987), can be taken either as support for the validity of this assumption or as an indication that chain multiplicity faults (Maresch et al. 1994) produce a similar degree of stabilization as this solid solution.