

## **Enthalpies of formation of tremolite and talc by high-temperature solution calorimetry —a consistent picture**

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### **ABSTRACT**

Molar enthalpies of formation of natural, near end-member tremolite and talc have been calculated from high temperature lead borate drop-solution calorimetry. Using three mutually consistent reaction cycles for each phase, the critical volatile component H<sub>2</sub>O was treated in fundamentally different ways, namely as the simple “oxide” [i.e., as the enthalpy difference ( $H_{T_{\text{Cal}}} - H_{298.15}$ ) only], or as the (OH)-component in both low and high water-content phases, respectively. The molar enthalpies of drop solution of all solid phases participating in the various reaction cycles (brucite, diopside, enstatite, calcite, magnesite, quartz) were independently measured. We corroborate that the dynamic gas flow techniques introduced by Navrotsky et al. (1994) are critically important for very hydrous phases such as brucite, but that this dynamic technique yields the same results as traditional static drop-solution techniques for phases with relatively lower water contents such as tremolite and talc. When these critical differences in H<sub>2</sub>O behavior are taken into account, it can be shown that drop-solution measurements on tremolite and talc over the last twenty years actually lead to similar and consistent results on the enthalpy of formation of these phases; reported differences are due to incorrect assumptions on the final state of H<sub>2</sub>O. Our refined values for the enthalpy of formation from the elements for ideal end-member tremolite and talc range from  $-12299.2$  to  $-12308.9$  kJ/mol and  $-5892.1$  to  $-5900.2$  kJ/mol, respectively, depending on the internally consistent data set used for the reaction cycle components. These values are identical within error to the results refined from various phase-equilibrium experiments and show that these two fundamentally different techniques can lead to a consistent picture on the thermodynamic properties of hydrous minerals, a conclusion that has been strongly questioned in the past.

Heat capacity data have been obtained for the same samples of tremolite and talc by differential scanning calorimetry in step-scanning mode in the range 50–500 °C and 50–400 °C, respectively. The following best-fit equations apply to the ideal end-members [ $T$  in Kelvin,  $C_p$  in in J/(mol·K)] in the range 298.15 to 800 K and 298.15 to 650 K, respectively:

$$C_p (\text{tremolite}) = 1335.77586 - 0.02378 T - 1.00400 \cdot 10^7 T^{-2} - 9678.23152 T^{-0.5}.$$

$$C_p (\text{talc}) = 1300.66304 - 0.03007 T - 1.31510 \cdot 10^7 T^{-2} - 8778.5468 T^{-0.5}.$$