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The enthalpy of formation and internally consistent thermodynamic data of Mg-staurolite

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ABSTRACT

The enthalpies of drop solution in lead borate ($2\ PbO{\cdot}B_2O_3$) of four Mg-staurolite samples, synthesized at 720 °C and pressures between 2 and 5 GPa, were measured by high-temperature oxide-melt calorimetry at 702 °C. Staurolite compositions, determined by electron microprobe analysis, Karl-Fischer titration, and thermogravimetry, are: $Mg_{3.71}Al_{18.17}Si_{7.60}O_{44.31}(OH)_{3.69}$, $Mg_{3.87}Al_{17.65}Si_{7.75}O_{43.68}(OH)_{4.32}$, $Mg_{3.66}Al_{17.76}Si_{7.68}O_{43.31}(OH)_{4.69}$, and $Mg_{3.58}Al_{18.05}Si_{7.43}O_{43.01}(OH)_{4.99}$. The enthalpy of drop solution of the bulk samples (as well as the calculated values for the enthalpy of formation from the elements of Mg-staurolite) are strongly correlated to the H content of the samples. The enthalpy of formation from the elements is best described by the linear relation $\Delta_f H^0_{298}$ (Mg-staurolite) = (–25357.58 + 87.35 *N*) kJ/mol, where *N* = number of H atoms per formula unit in Mg-staurolite. The enthalpy of drop solution of two partially dehydrated Mg-staurolite samples is in a good agreement with the linear relation. Phase-equilibrium data for Mg-staurolite (Fockenberg 1998) were recalculated using the stoichiometric formula $Mg_{3.5}Al_{18}Si_{7.75}O_{44}(OH)_4$. Based on these mineral equilibria and the internally consistent data set of Berman (1988), a mathematical programming analysis of the thermodynamic data of Mg-staurolite gave $\Delta_f H^0_{298}$ [$Mg_{3.5}Al_{18}Si_{7.75}O_{44}(OH)_4$] = –25005.14 kJ/mol, and S^0_{298} [$Mg_{3.5}Al_{18}Si_{7.75}O_{44}(OH)_4$] = 937.94 J/(K·mol). Thus, for the first time, reliable thermodynamic data for Mg-staurolite, based on experimental constraints, are provided.