

Calorimetric study of the surface energy of forsterite

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ABSTRACT

Surface energies are an important factor in determining surface reactivity, sintering, and transformation, yet, until recently, there have been few direct measurements for rock-forming mineral phases. Using calorimetric methodology we developed and first applied to aluminum and iron oxides, we present here the first direct measurement of the surface enthalpy of forsterite, Mg_2SiO_4 , based on high-temperature oxide melt solution calorimetry and water adsorption calorimetry. The measured surface enthalpies of hydrated and anhydrous Mg_2SiO_4 particles are 3.37 ± 0.21 and 4.41 ± 0.21 J/m², respectively. The measured water adsorption enthalpies for approximately first and second monolayer coverage are -102 and -79 kJ per mole of H_2O (liquid water reference state). Both the surface enthalpy and water adsorption enthalpy values agree well with values from atomistic simulations. The relatively high surface enthalpy of forsterite is greater than that of γ -alumina, maghemite ($\gamma\text{-Fe}_2\text{O}_3$), and MgAl_2O_4 spinel. This suggests that the surface energy of ringwoodite may be lower than that of forsterite, and that surface energy effects may thermodynamically favor the olivine-spinel transition, bringing it to lower pressures for small grains.

Keywords: Forsterite, calorimetry, surface energy, thermodynamics