Thermodynamic calculation of post-spinel phase boundary of Mg_2SiO_4

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The post-spinel boundary of Mg_2SiO_4 has been investigated by many researchers. However, obtained boundaries are different among the researchers and have not been well constrained yet. In this study, we redetermined the post-spinel transition enthalpy at 298 K, which greatly affects a thermodynamically calculated phase transition pressure, by precisely measuring drop-solution enthalpies of $MgSiO_3$ bridgmanite, Mg_2SiO_4 ringwoodite and MgO. The obtained post-spinel transition enthalpy was applied to the thermodynamic calculation of the post-spinel boundary together with recently reported entropies, heat capacities and thermoelastic data.

Mg_2SiO_4 ringwoodite and $MgSiO_3$ bridgmanite used for calorimetry were synthesized using a Kawai-type multi-anvil high-pressure apparatus at GRC. The drop-solution enthalpy measurements were performed using a Calvet-type twin micro-calorimeter. Samples of about 3 mg were dropped from outside of the calorimeter at room temperature into the $2PbO{\cdot}B_2O_3$ solvent placed in the calorimeter kept at 978 K. The solvent was stirred by Ar gas bubbles to hasten dissolution of the dropped samples.

Drop-solution enthalpies of Mg_2SiO_4 ringwoodite, $MgSiO_3$ bridgmanite and MgO were determined to be 128.75±1.99, 16.47±0.52 and 33.74±0.99 kJ/mol, respectively. From these enthalpy values, the post-spinel transition enthalpy at 298 K was obtained as 78.54±2.28 kJ/mol. Thermodynamic calculation of the post-spinel boundary suggested that phase transition pressure is lower than that correspond to the average depth for the 660-km seismic discontinuity (~23.5 GPa), which is estimated from PREM and ak135-f, and that most likely Clapeyron slope is about -1 MPa/K. Since the hydrous condition makes the post-spinel transition pressure higher and the Clapeyron slope steeper, water content in the mantle transition zone would give a plausible explanation for observed 30-40 km depressions of the "660-km" seismic discontinuity.