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Thermal conductivity of single-crystal brucite at high pressures: Implications for thermal anomaly in the shallow lower mantle

Yu-Hsiang Chien[1,2,3,*,†], Kai-Chi Wei[4], and Wen-Pin Hsieh[2,4,*]

[1]Earth System Science Program, Taiwan International Graduate Program (TIGP), Academia Sinica and National Central University, Taipei 11529, Taiwan
[2]Institute of Earth Sciences, Academia Sinica, Nankang, Taipei 11529, Taiwan
[3]College of Earth Sciences, National Central University, Taoyuan 32001, Taiwan
[4]Department of Geosciences, National Taiwan University, Taipei 10617, Taiwan

Abstract

Brucite [$Mg(OH)_2$] is an important hydrous mineral in the MgO-SiO_2-H_2O system and also a key component in the process of hydrothermal metamorphism. Due to its large water storage capacity and presence within a sinking slab, the study of brucite's physical properties under relevant extreme conditions could shed new light on its potential impacts on the slab's thermal profile and geodynamics, as well as seismic anomaly observed around a subduction zone. For example, seismic tomography has revealed slab stagnation and low-velocity zones in the shallow lower mantle that is conventionally attributed, respectively, to large contrasts of physical properties between the slab and mantle as well as dehydration melt. However, the effect of hydrous minerals on slab dynamics and seismic anomalies remains poorly understood. Here we study thermal conductivity of brucite at high pressures and room temperature as well as at ambient pressure and elevated temperatures. We further model thermal conductivity of brucite along a representative geotherm and find an ~6-fold to 19-fold increase in the thermal conductivity as brucite decomposes to periclase in the shallow lower mantle (~800 km depth). This result implies that the subduction and decomposition of brucite-rich aggregate within a slab may create a local high-temperature anomaly that would both enhance the slab's buoyancy, leading to stagnation, and facilitate dehydration melting, contributing to seismic low-velocity zones. Our findings offer mechanisms associated with brucite decomposition that could influence the slab dynamics and seismic structures in the shallow lower mantle.

Keywords: Brucite, hydrous mineral, anisotropic thermal conductivity, slab stagnation, dehydration melting; Physics and Chemistry of Earth's Deep Mantle and Core