Ultrasonic velocity of diopside liquid at upper mantle conditions: Constraints on velocity reduction due to partial melts

Man Xu[1], Zhicheng Jing[1], Julien Chantel[1,3], Peixiu Jiang[1], Tony Yu[2], Yanbin Wang[2]

[1] Department of Earth, Environmental, and Planetary Sciences, Case Western Reserve University, Cleveland, OH 44106, USA

[2] Center for Advanced Radiation Sources, The University of Chicago, Chicago, IL 60637, USA

[3] Unite Matériaux et Transformations, CNRS, Université de Lille, 59655 Lille, France

Abstract

Sound velocities of diopside liquid were determined at high pressures and high temperatures up to 3.8 GPa and 2375 K, using the ultrasonic technique combined with synchrotron X-ray diffraction and imaging in a multi-anvil apparatus. Our results show that the sound velocity increases with pressure but is nearly independent of temperature. Using a Monte-Carlo approach, the measured high-pressure sound velocities combined with ambient-pressure density provide tight constraints for the equation of state of diopside liquid, with a best-fit adiabatic bulk modulus (*Ks*) of 23.8 ± 0.4 GPa and its pressure derivative (*Ks'*) of 7.5 ± 0.5. The calculated adiabatic temperature gradient in a diopside liquid layer and its density profile suggest that a melt layer with diopside composition in the upper mantle would start to crystallize from the bottom of the layer and continue to crystallize upwards. By comparing our results with previous sound velocity measurements on silicate glasses, we demonstrate that the pressure dependencies of sound velocities in diopside liquid and glass are different. Thus, silicate glasses should not be used as an analog material for studying the acoustic properties of silicate liquids, as measurements on unrelaxed glasses do not capture the configurational entropy contribution to the compressional properties of liquids. We modeled velocity reductions due to the presence of partial melts in the upper mantle using our results and found that pressure has a large effect on the estimation of melt fraction. For a given velocity reduction, the deeper the low velocity region, the larger the melt fraction is required. Using silicate glass data for such estimation would result in a significant underestimation of melt fractions at high pressures.