Hugoniot measurements for silicate: Understanding silicate magma under the planetary impacts

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Two magnesium silicates of $MgSiO_3$(Enstatite) and Mg_2SiO_4(Forsterite) are primary mantle constitutions in the Earth and major components in Earth-type exoplanets.The ordinary chondrite, which accounts for about 90 % of all flying meteorites, consists of silicates as main components. The impacts at collision velocities exceeding 10 km/s are known as common events in the universe and such high energy phenomena could have played an important role to form planets or planetesimals and to evolve planetary environments. For example, a large-scale impact such as the giant impact related to the formation of moon was estimated to be at impact velocity of 15-20 km/s [Melosh, 1990].

In this study, Hugoniot equation of state (EOS) of enstatite has been determined at pressures of ˜400 to 560 GPa by laser shock experiments. A coupling of both the present study and the previous data by Fratanduono et al. (2018) shows a discontinuity in the shock velocity-particle velocity at ˜380-400 GPa. The measured reflectivity of shocked enstatite indicates three different trends relative to that of quartz; less steep slope at 300-345 GPa, parallel at 345-400 GPa, and a rapid increasing above ˜400 GPa, suggesting different phases of enstatite melt, a mixture of metal-like liquid of $SiO_2$and crystalline MgO, and fluid-like enstatite melt above ˜380 GPa. We also calculated the release state of thin enstatite using quartz on it as a reference. These results on enstatite imply that reactions in silicate magma occur at pressures of 300-400 GPa and that they may affect the current planet formation model in terms of the stratification of interior, the mantle convection, and the formation of magnetic field in Super-Earths.

