Shock Equations of State and Melting Temperatures of Fe-Bearing Silicates to 1 TPa

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The compositions of the cores and mantles of the terrestrial planets are determined by the chemical and physical conditions of accretion. Simulations show that giant impacts between planetary bodies in the early solar system are common and that they result in extensive melting and vaporization of the planetary material. The extent of mixing between these bodies will rely on the properties of these materials under the high-pressure, high-temperature impact conditions. Specifically, the melting curves and equations of state of both liquids and solids are necessary to model the behavior of proto-planets during impacts. Recently, a significant amount of work has gone into understanding the Mg-endmembers of silicate materials under shock conditions (Davies et al., 2018; Fratanduono et al., 2018; Root et al., 2018), but very few studies exist on more realistic Fe-bearing compositions (Holland and Ahrens, 1997; Luo et al., 2004). Further, we have shown that models of silicate equations of state do a poor job of reproducing the experimental results (Duncan et al., 2019). This is even worse for Fe-bearing minerals, as Fe has a complicated electronic structure that is difficult and expensive to model. To that end, we conducted decaying-shock measurements on natural olivine ($(Mg_{0.9},Fe_{0.1})_2SiO_4$) and bronzite ($(Mg_{0.9},Fe_{0.1})SiO_3$). We report shock equations of state of these minerals up to 1 TPa and constrain the melting temperatures of these minerals on the Hugoniot.

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