Crystalline forsterite to 160 GPa

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Metastable forms of forsterite, amorphous and crystalline, occur in rocks and in high-pressure experiments. Olivine glasses are found in meteorites, and are key indicators of shock impact conditions. A metastable polymorphs of forsterite, forsterite III, was recently observed at high pressure in static[1] and dynamic[2] compression experiments up to about 90 and 75 GPa respectively. The decomposition into its stable breakdown products ($MgO+MgSiO_3$) being kinetically hindered.

In order to further explore the nature of forsterite at high pressure, we compressed a pure crystal in quasi-hydrostatic conditions (He) up to 160 GPa at ambient temperature. The sample was probed with synchrotron hard x-rays. With about 20 peaks still present at the highest pressure we show that forsterite does not become amorphous, as powder diffraction studies suggested, but remains in the forsterite III crystal structure. More hydrostatic stress conditions and greater resolution of our experiment can explain this apparent discrepancy. Forsterite III is showing a remarkable metastable persistence range, up to at least $\sim$ 75 GPa and 2500 K for very high strain rates [2] and from about 55 GPa to at least 160 GPa at ambient temperature. Our results will be useful for the interpretation of shock compression experiments to greater pressures than so far achieved.

We will discuss the implication of our observations on understanding the shock history of meteorites from the analysis of olivine glasses. The persistence of a metastable crystalline forsterite phase in shock compression should be taken into account in the modeling of planetary-forming shock events.

[1] Finkelstein et al. (2014) *Amer Mineral*, ***99***(1), 35–43. [2] Newman et al. (2018) *Geoph Res Lett*, ***45***(16), 077996.