

## Formation of High-Pressure Silicate Phases in Shock Experiments

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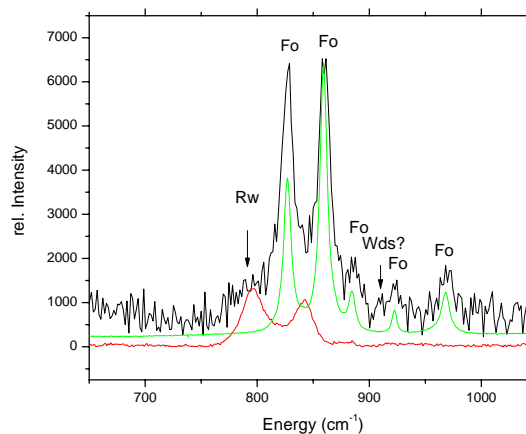
**The occurrence of high pressure silicate phases in shocked meteorites allows for estimating the size of their parent bodies: Growth rate and crystallite size of these minerals constrain the high pressure regime during shock. Shock duration is limited by rarefaction of the impact-induced shock wave travelling through the two collided objects. Thus, knowledge of growth rate and determination of crystallite size constrains shock duration and, indirectly, the parent body size at the stage of growth associated with impact velocities needed to generate a given intensity of shock metamorphism. We report growth of high pressure polymorphs of olivine from melt in a shock recovery experiment. This is the first direct observation of formation of high pressure Mg-silicate phases in a shock experiment and enables us to constrain growth rates of silicate phases under dynamic compression or upon shock release to 1- 10 m/s or higher suggesting at least partial control by turbulent mass transport rather than by diffusion. This implies that S5 to S6 level shock events in meteorite parent bodies may have had durations on the order of milliseconds. In the light of our findings, previous estimates of planetesimal size in the early solar system need a careful reevaluation.**

Our shock recovery experiment was conducted on two doubly polished disks placed face to face in a stainless steel recovery chamber. One disk was a pressed pellet of MgO with 50% porosity and one was fused quartz. A tantalum flyer plate launched at 1.53 km/s imparted shock into the sample chamber. From impedance match we calculate a peak pressure of 26 GPa achieved after multiple reverberations. Based on a recent numerical study [1] we estimate the temperature of MgO at 26 GPa to be between 2000 and 3000 K. A section of the sample was polished for examination. We used EBSD, synchrotron-based micro X-ray diffraction and micro-IR reflectance, and micro-Raman spectroscopy. X-ray diffraction and optical spectroscopy indicated presence of forsterite, wadsleyite and ringwoodite (figure 1) in the sample. Further, by EBSD scanning we could uniquely identify wadsleyite grains, determine their size, and clarify that these grains are embedded in silicate glass rather than forsterite (thus indicating growth from melt rather than solid-solid transformation). The silicate glass has a composition close to enstatite. Grainsize and the duration of the high-pressure regime during the shock experiments constrain the growth rate to be on the order of meters per second or larger. Diffusion-controlled growth is expected to be several orders of magnitude slower.

In sum, our data show that the time scale of shock experiments is sufficient to trigger silicate reactions and formation of silicate phases, when shock state and initial porosity are sufficient to drive at least local melting in the shock state. This provides for the first time an experimentally supported estimate of rates of chemical reaction and crystallite growth

of high pressure silicate phases under dynamic compression and release. The experimental growth rates suggest that shock-induced formation of silicate phases in meteorites can occur in the range of ms rather than seconds or minutes. These growth rates appear to be noticeably larger than those dictated by atomic diffusion and suggest relevance of turbulent mass flow for reaction and growth under shock and post shock conditions.

Figure 1: Raman spectrum of shock-recovered sample. The spectrum shows presence of forsterite and ringwoodite. Green and red spectra are from the Crystalsleuth database [3]. Forsterite and wadsleyite were also uniquely identified by EBSD.



References: 1: D. Stoeffler, K. Keil, E.R.D. Scott, *Geochim. Cosmochim. Acta* **55**, 3845 (1991), 2: Luo, S.N., et al (2004) *J. Phys.: Condens. Matter* **16** 5435-5442, 3: Downs, R. T. (2006), 19th General Meeting of the International Mineralogical Association in Kobe, Japan. Abstract # O03-13 We are grateful to M. Long, E. Gelle, and R. Oliver for experimental and analytical support. This work was supported by NSF grant 0552010, NNSA Cooperative Agreement DOE-FC88-01NV14049 and NASA/Goddard grants under awards NNG04GP57G and NNG04GI07G. Use of the HPCAT was supported by DOE, NSF, DOD, and the W.M. Keck Foundation. APS and NSLS are supported by DOE.