**PORPHYRITIC OLIVINE CHONDRULES: CONSTRAINTS ON FORMATION CONDITIONS FROM TEXTURES AND EXPERIMENTAL SIMULATIONS.** M. J. Zieg and G. E. Lofgren, NASA Johnson Space Center, Houston, TX, USA, 77058. michael.j.zieg1@jsc.nasa.gov.

**Introduction:** Based on several lines of evidence, we conclude that most porphyritic olivine (PO) chondrules were formed by partial (i.e., subliquidus) melting of olivine-rich precursor material. The melting event was followed by moderately rapid (on the order of 100°C/hr) cooling. Observed crystal size distributions and iron-rich overgrowths on the olivine grains in PO chondrules are consistent with the proposed cooling and growth rates.

**Partial Melting:** The recognition that most porphyritic chondrules did not crystallize from a complete melt has revolutionized the understanding of the physical conditions of chondrule formation. In particular, the role of nucleation in determining the texture is diminished if a significant proportion of the crystals in a chondrule are relicts. Incomplete melting also provides a partial explanation for the high abundances of alkalies and other volatiles in the chondrule mesostases. If chondrules were subjected to lower peak temperatures, the problem of volatilization is diminished. Partial melting of crushed UOC demonstrates that textures similar to those seen in some chondrules can be produced from subliquidus ($\Delta T \sim 100$-300°C) melting [1]. Crystal size distributions (CSDs) from higher intensity partial melting experiments ($\Delta T \sim 5$-50°C) closely match other PO chondrules from UOC and CO chondrites [2].

**Cooling Rate:** Extensive experimental simulation studies have established that textures resembling those of many PO chondrules can be produced by cooling rates on the order of 100°C/hr [3]. This is consistent with estimates from nebular shock models [4]. Given a temperature range of approximately 250°C between the liquidus and solidus of chondrule melts, cooling at these rates provides approximately 1-5 hours during which crystals can grow.

**Growth Rate:** The rate at which olivine crystals grew in chondrules is difficult to constrain. However, the evolution of textures during chondrule-simulation experiments is consistent with a growth rate ($dr/dt$) on the order of $10^{-7}$ cm/s. This is similar to olivine growth rates determined by other techniques [5]. A growth rate of this magnitude is also consistent with petrographic evidence. The thickness of Fa-rich rims on olivine in Type II chondrules is frequently in the range of 5 to 20 μm [6]. Assuming a crystallization interval of 250°C and a cooling rate of 100°C/hr, the production of a rim 10 μm thick would require a growth rate of $1.1\times10^{-7}$ cm/s.

**Summary:** The textures of porphyritic chondrules provide strong evidence for multiple episodes of melting, in which the peak temperatures remained below the liquidus. The relict grains were up to 100 μm in size at the end of the melting event, which means that the crystals did not have to grow to their final size during the last heating/cooling cycle. Cooling was relatively slow, on the order of 100°C/hr, which is consistent with chondrule formation in a comparatively dense region of the nebula. An olivine growth rate on the order of $\sim10^{-7}$ cm/s is consistent with the observed 5-20 μm thick Fe-rich rims on olivine grains in Type II chondrules, and with measured and inferred growth rates from crystallization experiments.

**References:** [1] Nettles J. W. et al. (2003) *LPS XXXIV,* #1823. [2] Zieg M. J. and Lofgren G. E. (2003) *LPS XXXIV,* #1384. [3] Lofgren G. E. (1989) *GCA, 53,* 461-470. [4] Desch S. J. and Connolly H. C., Jr. (2002) *MAPS, 37,* 183-207. [5] Donaldson C. H. (1975) *Lithos, 8,* 163–174. [6] Jones R. H. and Lofgren G. E. (1993) *Meteoritics, 28,* 213–221.