DEGREE OF MELTING IN CHONDRULE SIMULATION EXPERIMENTS.
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Abstract A synthetic chondrule mix of grain size 125-250μm was flash-melted at 1500-1625 °C and cooled along curves initially 25-61°C/min. Degree of melting ranged from 86-100%, as determined from abundance of relict olivine grains. Charges with abundant relicts do not resemble typical chondrules, which may have had finer grained precursors or have been melted for longer times.

Introduction The degree of melting in individual chondrules must be known if the nature of chondrule formation is to be fully understood. Porphyritic olivine (and other) chondrules are considered by some to represent very high (1) and others very low (2) degrees of melting, though degree of melting of chondrules is difficult to quantify. We have therefore done chondrule simulation experiments, in which melting was incomplete, and examined abundance of unmelted relicts for various thermal histories.

Technique A type IIA chondrule composition, consisting of 41% San Carlos olivine, 29% fayalite slag, 10% orthopyroxene, and 20% plagioclase, with a calculated liquidus temperature of 1550°C (3) was ground to 125-250μm. Pellets were inserted into a preheated DelTech furnace for melting at an fO₂ 0.5 log units below Fe-FeO and at various initial temperatures. Cooling was commenced after 15 seconds to simulate flash heating, using various stepped cooling profiles (Fig. 1) which approximated natural cooling curves and permitted crystallization. An image analysis program (VISTA) was used with a JEOL 8600 electron microprobe to measure the abundance of phases, including relict San Carlos olivine, in a central vertical slice through each charge.

Results Many charges showed sharp contacts between angular olivine grains of San Carlos composition and melt-grown overgrowths in BSE images. Degree of melting is naturally sensitive to initial (peak) temperature for constant heating time (Figs. 1 and 2). For cooling initially at 50° C/min, relict San Carlos olivine ranged from 0% with heating at 1625°C to 14% at 1500°C. For the same initial temperature, degree of melting varies with cooling rate: for 1575°C initial temperature, we have 1% relicts with an initial rate of 25°C/min and 10% with 61°C/min.

Discussion Some charges with PO/BO textures are essentially totally melted, in that they have no detectable relict grains. A difference of 100-125°C in peak temperature produces charges only 86-89% melted. A similar effect results from a factor of 2.4 change in cooling rate, as dissolution of olivine continues down to subliquidus temperatures and proceeds further with slower cooling. Our charges with such low degrees of melting do not much resemble common chondrules, which rarely show many large angular relict grains. There are several possible explanations. Chondrule melting could have been generally more complete due either to longer heating times or higher temperatures. Alternatively, chondrule precursors could simply have been much finer grained than our 125-250μm grains, so that melting produced inconspicuous relicts or simply nuclei: experiments on the same composition ground to 23-45μm (3) have inconspicuous relicts and degree of melting is hard to quantify.

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Fig. 1 Cooling Curves of Flash Heating Experiments
1575°C Initial Temperature

Fig. 2 Relics as a Function of Initial Cooling Rate and Temperature
Of Flash Heating Experiments with Exponential Cooling Rates

Precursor Material:
Type II bulk composition
125 – 250 micron grainsize
Pressed into 50 mg pellets