INTRODUCTION In LPSC XVII we reported the results of dynamic crystallization experiments on an intermediate type II-III chondrule composition and expressed the need to expand the range of experimental compositions. In this paper, we discuss the results of experiments on an average type I (MgO-rich) chondrule composition. This composition has an apparent liquidus of 1583 ± 2°C. Experiments were performed in a Deltech vertical muffle tube furnace with a Eurotherm controller. Experimental charges were mounted on Pt wire loops and cooled at continuous rates from temperatures above, near and below the liquidus. Seeded runs were performed in which a 1 mm grain of olivine (Fo89) was attached to the Pt wire to prevent settling. Ambient atmosphere of 0.5 log units below Iron-Wüstite was maintained by mixing CO and CO2.

TEXTURES Runs cooled from initial temperatures 100°C above the liquidus produced glassy spherules, except at 10°C/hr which resulted in spherulitic olivine texture. This observation demonstrates the ease of forming glass by low degrees of superheating, even for highly olivine-normative compositions. True porphyritic textures were produced by cooling at 100 and 10°C/hr from initial temperatures near and 30°C below the liquidus. Barred textures were produced in runs cooled at 1000°C/hr from the liquidus and in seeded runs from initial temperatures 4°C above the liquidus cooled at 1000, 500, and 250°C/hr. A similar seeded run cooled at 1000°C/hr produced a syntaxial overgrowth of olivine over the relict grain. A transitional texture containing a barred upper portion and a lower cumulate was produced at 30°C below the liquidus cooled at 1000°C/hr. This variation in texture, within the charge, results from the segregation of olivine crystals, leaving a liquid devoid of nuclei and with higher effective degrees of undercooling. This shifts olivine textural type to more skeletal morphologies.

ZONING Olivines produced in the 10°C/hr runs are essentially unzoned (Fo96) with K values close to the equilibrium value of 0.3. Olivines in the more rapidly cooled runs are normally zoned with cores Fo96-97 and 4 - 5 mole percent variation in Fa. Ca contents generally increase with Fa content but this relationship is not evident in all grains. K values in these runs decrease with increasing cooling rate, although there is considerable overlap in the values for 100 and 1000°C/hr.

DISCUSSION The porphyritic olivines produced in these experiments differ from the natural (and those reported for type II-III composition) in two ways: 1) Fo content is higher; 2) Smaller range of compositional zoning. These differences are attributed to the MgO-rich nature of this composition and the associated high temperatures of crystallization. Dynamic crystallization experiments indicate that barred olivine textures form from droplets heated to near the liquidus with few nuclei (or a single nucleus) and cooled a rates greater than 100°C/hr.
The apparent lack of zoning in natural barred olivines may indicate cooling rates near the lower limit. Porphyritic olivine texture forms at any rate from initial temperatures below the liquidus, and at lower rates from near the liquidus. The strong compositional zoning observed in natural PO chondrules requires cooling rates greater than 100°C/hr. The skeletal olivine morphologies produced in experiments at these rates appear to be a direct consequence of gravitational settling. Granular textures are formed by low degrees of melting of precursor material (liquidus - 40°C). We stated previously that the paucity of glassy chondrules suggested that chondrule precursors were not superheated. This conclusion is supported by an apparent correlation between olivine normative composition of chondrules and textural type (see fig. 1). The sequence: type I (granular) to Type II (porphyritic and barred) to Type III (excentroradial and cryptocrystalline, pyroxene normative) defines a trend of increasing degrees of melting (and destruction of nuclei) with decreasing normative olivine. This hierarchy strongly suggests that a ceiling temperature existed. The predominance of granular texture for MgO-rich compositions with the occasional occurrence of MgO-rich barred olivine chondrules, suggests a maximum temperature of 1580°C.

References
Radomsky et al. (1986) LPSC XVII, 687-688.

Fig. 1 Data in wt %, from McSween (1977).