INFLUENCE OF MELTING KINETICS ON THE FORMATION OF BARRED OLIVINE CHONDRULES. Roger H. Hewins, Patrick M. Radomsky and Harold C. Connolly, Jr., Geological Sciences, Rutgers University, New Brunswick, NJ 08903

Introduction Dynamic crystallization studies of chondrules have followed petrologic tradition by defining the intensive parameters of chondrule melting, such as initial temperature. We are confident that BO and PO (type-A zoned) chondrules formed from near- and sub-liquidus temperatures respectively (below a maximum of 1700°C) at cooling rates in the range 100-1000°/hr (1-3). Given these conditions, chondrule textures are controlled to a large extent, but indirectly, by bulk composition (4). Specifically, however, they are controlled by the number of nuclei remaining after melting. Therefore, in chondrule experiments, we must also investigate extensive parameters, such as spherule volume, which influence melting kinetics and therefore influence survival of nuclei.

Barred Olivine Texture Using the optimum cooling rate, 500°/hr, defined by (3), we have extended the work of (4) to map out the occurrence of BO texture as a function of composition (Fe/Mg) and initial temperature. Fig. 1 shows the BO field determined at 1556 and 1610°C. Since we could not achieve melting temperatures for the most magnesian composition, we doped it with feldspar to determine a BO field (3), which is then plotted by normalizing temperatures to the calculated liquidus temperature of the undoped sample. As shown in Fig. 1, melting temperature must be just below the apparent liquidus to yield the number of nuclei for BO texture, or else glass or PO texture is formed.

Effect of Sample Size We simultaneously cooled three charges of an intermediate composition, 1mm, 2mm and 4mm in diameter, from just above the equilibrium liquidus at 500°/hr and quenched them from 1060°C. The smallest was glass, the intermediate had a transitional BO/PO texture and the largest had a PO/hopper PO texture, because of the different extent of melting during the 30 minutes at the initial temperature.

In our experiments with 30 minute melting times for the most magnesian composition, we determined an apparent liquidus of 1597°C for 4mm charges, and 1585 for 2mm charges, as compared to a calculated equilibrium liquidus of 1567 (3). The experimentally determined field for BO texture is plotted in Fig. 2 for 4mm charges and extended to the BO field for a Type II/III chondrule composition determined by (3). The BO field for 2mm charges and an extrapolated BO field for extremely small spheres are also plotted in Fig. 2, to emphasize that the textures are as much controlled by extensive as by intensive parameters.

Effect of Grainsize Most of our experiments were made with finely powdered starting materials, but we also seeded some runs with large olivine grains. The seeds had little effect on PO textures, but the surviving single grain in strongly superheated melt became overgrown to give BO texture where otherwise we would have formed glass. Such runs are plotted in Fig. 2 and extend the field for BO texture much above the apparent liquidus. We are making more systematic evaluations of the effect of grainsize, coupled with initial temperature and heating time.

Effect of heating time Glass and BO formed with 30 minute heating time are replaced by transitional PO/BO textures with 12 minute melting (4). The potential exists that a chondrule texture matrix significantly different from that of (3), in terms of initial temperatures, could be developed with different heating times and starting-material grainsizes.

Discussion In the traditional-style dynamic crystallization study we have a very narrow window for forming BO and many more glassy spherules than encountered in nature (2,3). Recognition of the role of chondrule size and seeds alleviates this problem. Both the low cooling rates (relative to radiation in a vacuum) and the great variety of foreign inclusions in chondrules are consistent with high particle densities. Impingement of foreign particles onto incompletely melted droplets would have had no effect, as PO chondrules would still have formed, but insertion and nucleation in totally melted droplets could have caused BO chondrules rather than glass. Similarly, large precursor grains might promote BO texture instead of glass, if one or two relicts survived melting of smaller precursor grains.

Conclusions Because spherule size, precursor grainsize and melting time affect the survival of nuclei, they are as important to chondrule texture as initial temperature. The abundance of BO chondrules is probably due to high particle densities in the solar accretion disk or to the occurrence of a range of grainsizes in the precursor particles.

References (1) Radomsky, P.M. and Hewins, R.H. (1987) Lunar Planet. Sci. XVIII, 808-809, (2) Radomsky, P.M. and Hewins, R.H. (1988), Meteoritics 23, 297-298, (3) Radomsky, P.M., M.S. thesis, Rutgers University, 96 pp., (4) Connolly, H.C., Jr., Radomsky, P.M. and Hewins, R.H. (1988) Lunar Planet. Sci. XIX, 205-206.

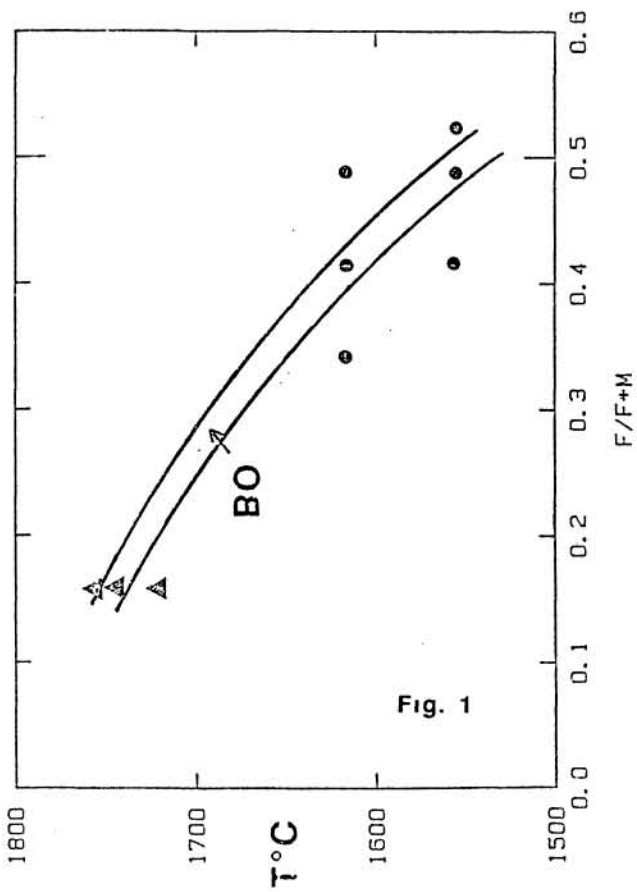

Fig. 1

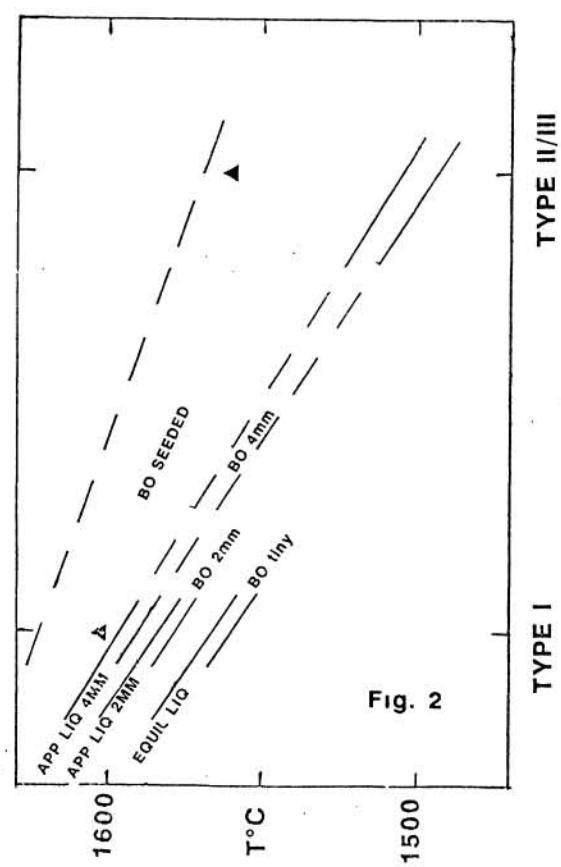

Fig. 2