THE EXPERIMENTAL PRODUCTION OF CHONDRULE RIMS: CONSTRAINTS ON CHONDRULE RIM ORIGINS Harold C.Connolly Jr. and Roger H. Hewins Dept. of Geolgical Sciences, Rutgers Univ., New Brunswick, NJ 08903

INTRODUCTION Experiments reproducing chondrule rims have been limited (1,2) and therefore the relationship between chondrule formation and rim formation is poorly understood. New experiments presented below on rim formation place constraints on existing models for chondrule rim formation.

EXPERIMENTAL TECHNIQUE Experiments were performed in a vertical muffle tube furnace at 1 atm with a controlled fO_2 at 0.5 log units below the Fe-FeO buffer curve. Two series of experiment were performed utilizing different techniques. The first series utilized a puffer (2) to produce a dust cloud within the furnace during the formational history of a synthetic chondrule. The second series utilized Bjurbole and synthetic chondrules that were dipped in acetone and covered with a desired composition as rim dust. The new charge with the dust was then inserted into the furnace at a desired temperature. Both series of experiments used Fa100 slag and Slag mix 1 (72.86%Fa100 slag; 12.86%An_{50} 14.29%Opx) and two different grain sizes. The first grain size ranged from 50-600 microns and the second grain size ranged from 23 microns to submicron sized particles.

RESULTS In the first series of experiments a pellet was heated in the furnace to create a melt sphere, then cooled. At or below solidus temperatures, dust was introduced into the furnace with a puffer (2). With 50-600 micron Fa100 slag dust, sintering to the charge occurred within 2 mins. Continuing dust encounters caused grain to grain sintering, and hence rim growth. Optimum sintering occurs between 1000-1100°C. Dust encounters above 1100°C result in melted rim textures or affect crystallization of the charge. Below 1000°C the lower the temperature, the weaker the sintering and rims which form below 900°C disintegrate. Preliminary experiments with grain sizes of 23 microns and less show optimun sintering temperature from 900-1000°C. Neither grain size range shows any grain growth and preliminary experiments with Slag mix 1 show no change in mineralogy.

The second series of experiments reproduced chondrule rims by using cold Bjurbolè or synthetic chondrules, dipping them in acetone as a glueing medium, and then covering them with cold dust. These experiments were suggest by Alan Rubin (pers.comm.) to understand if coarse grained rims can be formed from fine grained rims (3). Experiments utilizing Fa100 slag of 50-600 micron grain sizes ranged in temperatures from 500 to 1200°C and heating times from 3 to 120 mins. Sintering from 500-900°C produced poorly sintered rims that disintegrated when removed from the sample rod. Rims formed between 900-1100°C are well sintered, with optimum sintering occurring from 1000-1100°C. Rims formed above 1100°C had melted textures. A Bjurbole chondrule that was heated at 1059°C for 10 mins. produced a rim, but the pore spaces in this rim are filled with Fe-Ni metal and sulfides that migrated from the chondrule to the rim. Experiments at longer times for the same temperature show no Fe-Ni metal or sulfides. Preliminary experiments using grain sizes of 23 microns and less show optimum sintering temperature of 900-1000°C. Temperatures in excess of 1000°C produce rims with melt textures. Neither grain size in either type experiments show any grain growth. Preliminary experiments with Slag mix 1 show no change in mineralogy or grain growth.

DISCUSSION Dust encountered by a synthetic chondrule at or below its solidus produces rims. Subsequent dust encounters at or below solidus temperatures produce grain to grain sintering, and hence rim growth. Dust encountered above solidus temperature can affect crystallization within the charge, and encounters at low temperatures do not sinter. Multiple dust encounters of different grain sizes can produce layered rims during a single cooling event. Reheating of synthetic and natural chondrules that have dust stuck to them also produce rims. Layered rims may be produced by reheating of cold chondrules and dust, but many heating events are needed. The simplest origin for layered rims is therefore continued dust encounter during initial chondrule cooling.

Both series of experiments have shown that rim formation is dependent on the temperature of sintering and amount and grain size of the dust. Rim dust that ranges between 50-600 microns forms a well sintered rim between 1000-1100°C, whereas grain sizes from 23 microns and below sinter best between 900-1000°C. Poor sintering is observed below these obtimum temperatures and textures indicative of melting occur above these temperatures. Both series of experiments show that the sintering of rim dust to a chondrule or charge occurs in 3 mins. and rims heated near 1100°C for 120 mins. or more begin to equlibrate with the enclosed chondrule. Rim aquisition can therefore occur in a few minutes to an hour. No grain growth was observed in either series of experiments. One unique result of the reheating experiments was the mobilization of Fe-Ni metal and sulfides from a Bjurbole chondrule to the rim material. Neither rim material nor synthetic chondrule compositions contain Fe-Ni metals or sulfides and synthetic sulfide-bearing charges shall be the focus of future experiments.

CONCLUSIONS Experimentally it is possible to similate chondrulee rims by at least two methods; (1) The acquisition of dust at or below solidus temperatures by a synthetic chondrule during its formational cycle; (2) reheating of chondrules that have dust stuck after "quenching". Based on these experiments we conclude that for the studied grain sizes coarse grained rims cannot have been produced from fine grained rims. Concentric rim formation and layered rim formation is best consistent with dust encounters during initial cooling of chondrules in a nebular seeting.

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