
INTRODUCTION Many chondrules show fine-grained or coarse-grained accretionary rims (1). Rims have been simulated experimentally by allowing dust to collide with a cooling melt droplet and by reheating cold chondrules and spherules coated with dust (2), as well as by hypervelocity impacts into porous media (3). The simplest mechanism appeared to us to be dust-chondrule collisions in the nebula. Rims would then be a natural part of the chondrule-forming process and no other events are required (2). However, coarse-grained rims (CGR) might require conditions that promote perfect sintering of initially coarse particles. We have therefore reexamined the production of rims by reheating cold dust-coated spherules, with emphasis on the kinetics of rim-coarsening and chondrule modification for comparison with natural chondrules with coarse grained rims.

EXPERIMENTS Reexamination of synthetic chondrules that were covered with Fa slag dust and reheated to produce rims (2) and new reheating experiments indicate that all of the synthetic chondrules experienced some secondary thermal alteration upon reheating. New experiments are establishing controls for the effects of reheating. Three synthetic chondrules were initially formed at the same time. After quenching, one charge was removed and analyzed as a control. A second charge was then covered with rim dust and replaced into the furnace along with a third charge that is not covered with rim dust.

The best indicator of thermal alteration within rimmed and unrimmed charges is the mesostasis. The devitrification of the glassy mesostases begins within five minutes of reheating at temperatures ranging from 500°C to 1050°C (higher temperature allows near total melting of mesostasis which often flows into the rim material). Crystallites produced by reheating often have a chain-like morphology (4). In natural chondrules, similar chain-like crystals are thought to be quench crystals produced by rapid cooling (5). Currently, experiments are being conducted to determine if quenching temperatures can affect the stability of the glassy mesostasis upon reheating.

The reheating process affects the charges from their surfaces inwards towards the center. For short duration heating (5-30 mins.) the outer 20% of the charges show mesostasis devitrification while the interior mesostasis is unaffected. Type I, II, II/III composition charges (5,6) that have been reheated for one hour or more at temperatures ranging from 800°C to 1050°C have little glassy mesostasis surviving (<10%).

Mineral phases are also affected by the reheating of synthetic chondrules. Only olivines are present in Type I and Type II charges whereas pyroxene is also present in Type II/III. Reheating times of 5 mins. at temperatures ranging from 900°C to 1050°C show that Fe-Mg diffusion between mesostasis and olivines has begun. Primary zoning is altered as phenocrysts become more fayalite-rich. The outer 20% of the charges is first affected by the reheating. Phenocrysts may show normal zoning (sometimes irregular) with the edge of a crystal twice as rich as in non-
CHONDRULE MODIFICATION & RIM FORMATION: Connolly H.C. and Hewins R.H.

reheated charges. With heating times of 2 hours at 800°C Type I composition charges have olivines that are nearly equilibrated. Type II/III composition charges show that olivines in contact with mesostasis have increased fayalite contents from core to the edge of crystals (50-75 mol%) and those poikilitically enclosed by pyroxenes show no change of original chemistry.

Little obvious chemical interaction between charges and their rims takes place within short reheating times. Heating times of one hour or more indicate enrichments that are focused in 2 areas: (1) phenocrysts (whole or cracked) that are in direct contact with the rims; (2) cracks within the charges that are near the rim/sphere interface and phenocrysts along these cracks.

The synthetic rims produced were described by (3). In those experiments and in new experiments we have not produced coarse-grained rims from fine-grained material. For our experiments the grain size of the rim is a function of the original grain size of the material used.

DISCUSSION Rubin (1) describes several CGR chondrules in detail. Some are glass-free and contain plagioclase, which occurs more generally in chondrites as a result of metamorphism. Type I CGR chondrules in Semarkona have much lower CaO than other Semarkona Type I chondrules (1,7). Loss of CaO from forsteritic olivines is associated with metamorphism (8,9). It seems likely then that many CGR chondrules experienced very different thermal histories from normal chondrules in unequilibrated chondrite, either very slow initial cooling or reheating (though some still contain some glass and fairly heterogeneous olivines). The spectrum of textures in CGR chondrules includes BO and RP (1) so crystal growth rates and cooling rates were probably normal. A reheating event is therefore implied, particularly as some chondrules were sufficiently cooled to fracture before acquiring a CGR (1).

It appears unusual that there might be two kinds of nebular heating mechanisms, one which virtually totally melts aggregates to produce chondrules and another which heats close to the solidus so as to promote grain growth in rims and equilibration of chondrules. Continued experimentation will document the modification of chondrules during rim-sintering. There is a need for a detailed comparison of chondrules with and without CGR to check for differences in thermal history. This will throw light on the nature of the reheating mechanism.

CONCLUSION The reheating of synthetic chondrules covered with dust to produce accretionary rims affects the chemical and textural nature of the charges within 5 minutes of reheating. Natural rimmed chondrules that show no signs of thermal processing could not have accretionary rims formed by a reheating event.