**Compound Chondrules and Igneous Rims: Multiple Heating of Chondrules.** Harold C. Connolly Jr. and Roger H. Hewins. Department of Geological Sciences, Rutgers University, PO Box 1179 Piscataway, NJ 08850-1179.

**Introduction** Understanding the formation of independent compound chondrules and igneous rims (IR) could provided insight into the frequency and intensity of melting events within the chondrule-forming region(s) of the nebula (1,2). Experimental reproduction of independent compound chondrules by (3) showed that for the experimental conditions used, independent compound chondrules could only be formed from the collision of molten or semi-molten droplets. We report here on several additional experiments with porous dust coatings on charges that attempt to reproduce independent compound chondrules and actually form the igneous/melt rims reported by (2).

**Experimental Technique** Experiments were performed on a Deltech vertical muffle tube furnace. The $fO_2$ of the system was maintained with a mixture of CO and CO2 to 0.5 log units below the Fe-FeO buffer curve. The type IIAB composition ($T_L$=1504°C) of (4) and the type IIA composition ($T_L$=1556°C, initial grain size of 20-44μm) of (5) were used to manufacture synthetic chondrules with POP or PO textures. These charges were then separately covered with either the Fa-rich starting material (TL=1211°C, initial grain size of 20-44μm) of (6) or the type IIA composition of 5. Polyvinyl alcohol was used to make a porous coating of dust around the charges, varying in thickness (the rim dust, without synthetic chondrule, weighed from 50mg to 150mg depending on the experiment). Charges were then placed into a hot furnace that was not as hot as the initial melting temperature that formed the synthetic chondrules and flashed melted, with linear cooling of 500°C/hr.

**Results** Charges made from type IIA starting material covered with type IIA dust show only large phenocrysts remaining from the primary chondrule (fig.1). These charges look similar to some type IA chondrules, but they are much too Fe-rich to be considered type IA. Experiments performed with type IIAB primary chondrules and covered with Fa100-rich starting material show no distinct boundary between the primary chondrules and the new material. They also have considerable overgrowth of new material on the primary's "boundary" (fig 2).

Several charges fell off the sample rod during placement into the furnace. These charges were truly "flash melted" and received no linear cooling. The primary chondrule boundary is largely preserved. Numerous relict San Carlos grains exist in the "rim material" , with anhedral to subhedral crystals.

**Discussion** From these preliminary experiments it is clear that IR could have been formed from chondrules that were coated with porous mineral dust and experienced a flash melting event that was lower in temperature than that which created the enclosed chondrule. It is not clear to these authors what the difference truly is between IR and independent compound chondrules by the model of (2). If phenocrysts in the secondary chondrule (or rim) are zoned, then a certain cooling path is required. Furthermore, overgrowths on any surviving grains, whether isolated minerals or whole chondrules WILL occur. This is not a process unique to chondrules and must be considered when discussing the formation of objects like independent compound chondrules. We interpret our experiments (3) to suggest that independent compound chondrules formed by the collision of a solid chondrule with a semi-molten chondrule. Collision of a solid chondrule with a completely molten chondrule WOULD induce nucleation, with the solid chondrule acting as a nucleation site PROVIDED slow cooling was occurring. It is quite clear to the authors that the IR's described by (2) likely formed as they suggest, and these chondrules have indeed recorded multiple heating events.

PO Chondrules that were covered with dust of similar composition could have produced new textures with no "relict" chondrule present after flash melting. It is possible that type IA textures that have a few large relict grains with much smaller phenocrysts could represent such chondrules. If this is true, and 2 states "...that the amount of remelted chondrule material (in IR) was commonly large and always difficult to estimate." some chondrules could have experienced a second heating event almost, if not as intense as, the event that formed the primary chondrule. It may be that IR and chondrules have recorded gradations in the temperatures or duration of multiple melting events. Therefore, statements concerning the overall decrease in the intensity of the chondrule forming event(s) should be cautious.

This issue is clearly very interesting and may provide constraints on the frequency and intensity of melting events as well as the nature of chondrule precursors and rim material. We will explore the issue further in the future.

**Multiple Heating of Chondrules**. Connolly and Hewins.

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**Acknowledgments** We thank Julie Paque for her generous gift of polyvinyl alcohol and A. Krot, J. Wasson and A. Rubin for numerous discussions that always make us think and evaluate our experiments. This research was supported by NASA-NAGW 3391, Roger H. Hewins, PI.

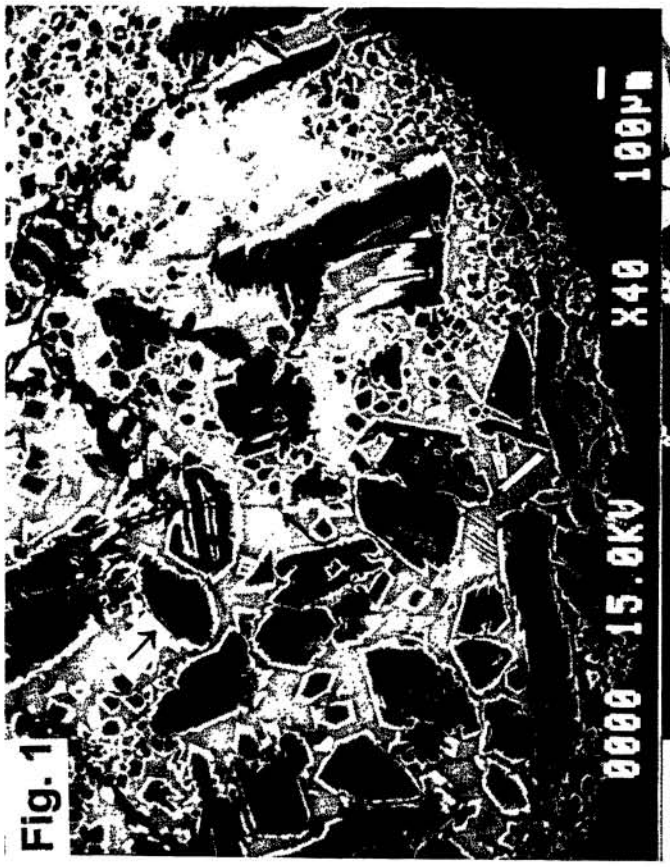


Fig. 1

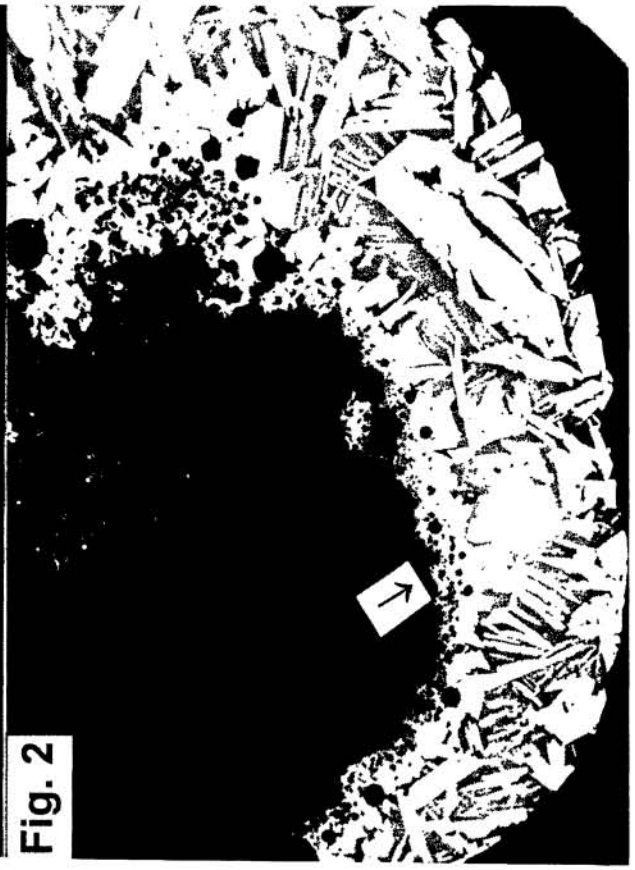

Fig. 2

Figure 1. A type IIA starting composition chondrule that was covered with type IIA starting composition and flash melted/cooled. The texture is largely MPO, with a few large grains that are relicts from the primary chondrule (arrow).

Figure 2. A type II/III chondrule that was covered with a Fa-rich starting composition and flashed melted/cooled. No clear boundary exists on the primary charge and overgrowths have occurred (arrow), and the primary chondrule is being absorbed.