MANY CHONDRULE MELTING EVENTS; MULTIPLE OVERGROWTHS IN CHONDRULES AND RECYCLED GRAINS. LIGHTNING AS HEAT SOURCE

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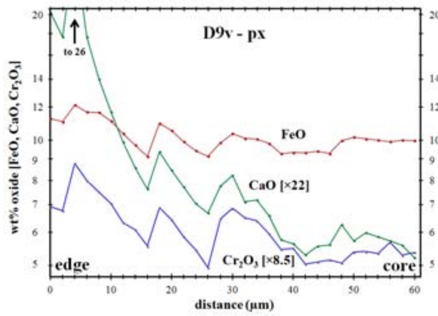
Some low-Ca pyroxene (px) phenocrysts in high-FeO Semarkona chondrules show eight or more multiple overgrowth layers [1]. Overgrowth layers are frequently preserved in pyroxene, but seem to have been smoothed out by diffusion in olivine. EMP traces in pyroxene show igneous zoning profiles that indicate a series of large and small melting events. Figure 1 shows profiles for Fe, Ca and Cr in chondrule D9v in AMNH Semarkona section 4128-2; the scale is logarithmic. There is a general increase in each of the elements from the interior on the right towards the edge (and the border to mesostasis glass) on the left.



Minima are the result of melting events; the deeper the minimum, the larger the amount of heat deposited; the best record is provided by Ca, which shows deep minima at 42, 26, 16 and 2 μm. Minor minima such as those at 38 and 32 reflect the deposition of smaller amounts of heat and less mesostasis melting.

Three sets of three compositional profiles in adjacent phenocrysts in another chondrule show the same major events. However, only one profile shows a regular increase in Ca contents of the major minima from center to edge; the other two show the deepest minimum in the 3rd of 4 minima. This implies that the amounts of deposited heat differed on a scale of ~20 μm.

It is difficult to find phenocrysts that show simple overgrowths; most pyroxenes record more complex textures. One px phenocryst appears to be a relict grain that formed in an earlier chondrule. It shows irregular banding and is crossed by a narrow px lamella, but symmetrically oriented bands still show igneous zoning with Fe and Ca increasing in the center-to-edge direction.

The number of major and minor melting events recognizable in high-FeO chondrules is commonly about 10. This requires a repeatable heat source, but (to explain differences in heat deposition) one that can deposit differing amounts of energy on a short (ca. 20 μm) distance scale. It appears to us that lightning best accomplishes these assignments. A plausible source of energy would be friction between larger particles in the dust-rich nebular midplane and finer particles in the adjacent gas-rich layers.

Charge separation is well known in dusty environments such as volcanos [2]. Triboelectric charge separation in dusty environments continues as long as there is turbulence. There are various possible effects that could serve to increase the breakdown potential in the low-pressure solar nebula.

References: [1] Wasson J. T. et al. (2014) *Lunar Planet. Sci*. 45, 2883pdf; [2] Cimarelli C. et al. (2014) *Geology* 42:79-82.#