Constraining the cooling rates of chondrules

Conference or Workshop Item

CONSTRAINING THE COOLING RATES OF CHONDRULES

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Chondrules are up to mm-sized spherical melt droplets that are the main component in chondritic meteorites, constituting up to 80 vol % [1]. They are products of widespread but poorly understood heating events in the early Solar System. Most chondrules have experienced complete or extensive melting, destroying much of what could be learned from the melting event. It is therefore the cooling event which provides the best record of chondrule formation conditions. Previous attempts to determine chondrule cooling rate have provided rates varying from 0.7 to 2400 Khr^{-1} [1, 2, 3]. Many FeO-rich chondrules contain MgO-rich relict cores within olivine phenocrysts. These are precursor grains which failed to melt [4, 5]. Partial equilibration between relict and overgrowth crystal during sub-solidus cooling creates a diffusion profile for a number of elements, which can be used to determine the cooling rate [3]. In BSE images, the olivine phenocrysts appear relatively bright and the relicts appear as dark patches within these phenocrysts e.g. Fig. 1 [5]. Diffusion profiles across the relict/overgrowth interface have been measured using EDS detectors and by calibrating greyscales (e.g. Fig. 2).

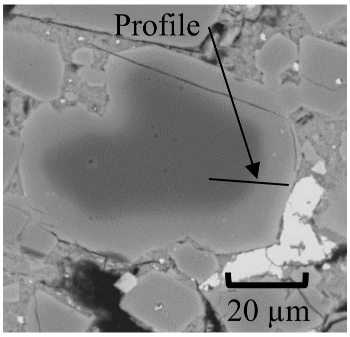

Fig. 1: BSE image of a relict grain from a chondrule in ALHA 77307.

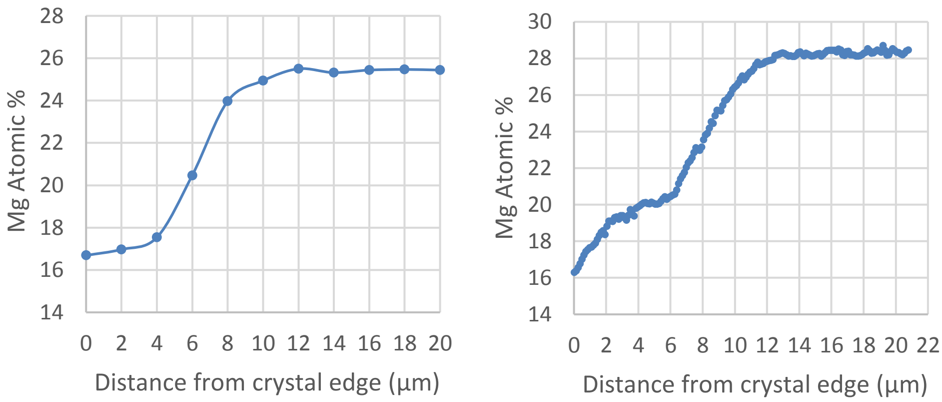

Fig. 2: diffusion profiles obtained by a) EDS detectors and b) a calibrated greyscale for relict grain shown in Fig. 1

The fastest cooling rates produce diffusion profiles at a scale of a few microns across. Measuring these requires a technique with high spatial resolution and sensitivity, such as NanoSIMS. Diffusion profiles for minor and trace elements will be measured across the relict/overgrowth interface using the Cameca NanoSIMS 50L at the Open University. A binary element diffusion model will be used to calculate cooling rates for each diffusion profile. The compatibility of current models for chondrule formation will be assessed and new possible models developed.

[1] Hewins R et al. 2005 in: *Chondrites and the Protoplanetary Disk* **34** 286-316
[2] Miyamoto M et al. 2009 *MAPS* **44** 521-530
[3] Hewins R et al. 2009 Abstract #1513 40th LPSC
[4] Jones R H 1990 *GCA* **54** 1785-1802
[5] Wasson J T and Rubin A E 2003 *GCA* **67** 2239-2250
[6] Morgan D and Blake S 2006 *CMAP* **151** 58-70

Acknowledgements: This work is funded by an STFC PhD studentship (to SCS). We would also like to thank the MWG, NASA JSC for loan of the samples that make this work possible.