COMPOSITIONAL CONSTRAINTS ON FORMATION MODELS FOR FINE-GRAINED RIMS. S. J. Hammond[1], S. H. Gordon[1], N. W. Rogers[2], B. L. A. Charlier[2] and P. A. Bland[1]; [1]Impacts & Astromaterials Research Centre (IARC), Dept. Earth Sci. & Eng., Imperial College London, South Kensington Campus, London SW7 2AZ, UK (s.hammond@imperial.ac.uk); [2]Dept. Earth Sci., CEPSAR, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK.

Introduction: Coarse-grained chondrule rims in Allende [1] appear to show a monotonic depletion pattern, significantly depleted compared to matrix, and slightly depleted compared to bulk. Fine-grained rims (FGR) in Renazzo [2] show a similar pattern. However, the difficulty in obtaining abundant matrix/rim separates for INAA [1,2], uncontaminated by adjacent components, requires that we be cautious in drawing conclusions based on the modest observed difference between matrix and rim compositions. Analysing FGR major element compositions, Chizmadia et al. [3] found that rims around chondrules and CAIs in ALHA 77307 were indistinguishable. Unfortunately, ALHA 77307 does not appear to contain distinct matrix with which to make a comparison.

Recent laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) work has demonstrated that matrix is depleted in volatiles relative to CI, and that different chondrite groups have distinct matrix compositions [4]. These factors suggest that fine-grained materials drawn from different parts of the disk will have distinct compositions. Thus, the presence or absence of compositional difference between FGRs around chondrules and CAIs, and matrix in the same chondrite, can place constraints on formation models. For instance, the X-wind model [5] suggests that CAIs, chondrules, and fine-grained chondrule rims formed close to the proto-Sun (~0.06AU), before being carried out to fall onto a ‘cold’ accretion disk composed of thermally unprocessed fine-grained nebula material. This is a variant of the two-component model: in this scenario, non-fragmental matrix (matrix without chondrule fragments) should be of CI-like composition, while FGRs (which derive from material forming close to the proto-Sun) may show some depletion.

In this initial study we present detailed *in-situ* trace element data from both matrix and fine grained chondrule rims within a section of the CV chondrite, Vigarano. LA-ICP-MS allows selection of highly specific sites for analysis (60 µm resolution) - matrix and FGRs can be distinguished with ease. Subsequent work will compare the trace and minor element composition of FGRs around chondrules with those around CAIs, and extend the dataset to other chondrites.

Methods: LA-ICP-MS was carried out at the Open University on an Agilent 7500s ICP-MS coupled with a New Wave 213 Nd:Yag deep UV (213 nm) laser system. Instrumental operating conditions are summarised in Table 1. Samples are ablated in a pure He atmosphere, and the analyte carried in He and then mixed with Argon via a ‘‘Y’’ connector before entering the plasma. The use of He gives a 2–3 fold increase in sensitivity, and significantly reduces background intensity (e.g. [6]). Data were acquired across the mass range from ^{7}Li to ^{232}U. The total time for each analysis was 220 s. During the first 100 s, the gas blank is measured, during which the laser beam is blocked by a shutter. This shutter is then removed, the sample is ablated for 60 s, and the transient signals from the analyte are acquired for a further 60 s. A 200 s wash out period was carried out between analyses. Interactions between the laser and sample has previously been investigated [4] and is shown to have no effect on analytical volatile fractionation under the energy conditions used in this study. Data reduction was carried out using the GLITTER software [7].

Analyses were normalized to an external glass standard (NIST 612). The standard was analysed twice at the start and end of each run. Detection limits are usually between 1 and 10 ppb range [8]. Data are ratioed to CI chondrite, and Yb.

Scan Parameters	**Conditions used**
Detection modes	Dual (analogue and pulse detector)
Dwell time	10 ms
Integration time	10 ms
Laser	
Laser	UP-213 (New Wave Research)
Type	Nd:YAG frequency quintupled
Wavelength	213 nm
Repetition rate	10 Hz
Spots	
Ablation duration	60 s
Spot size	60 µm
Energy	0.35 mJ

Table 1. LA-ICP-MS operating conditions.

Results: Fine grained chondrule rims are texturally distinct from bulk matrix (Figure 1). Rim material is richer in Fe than surrounding matrix, and surrounds both chondrule and CAI components within Vigarano. Rim thicknesses are variable (up to 80 μm thick), both between and within individual rims, with the fine grained material filling in embayed margins of the chondrule or CAI.

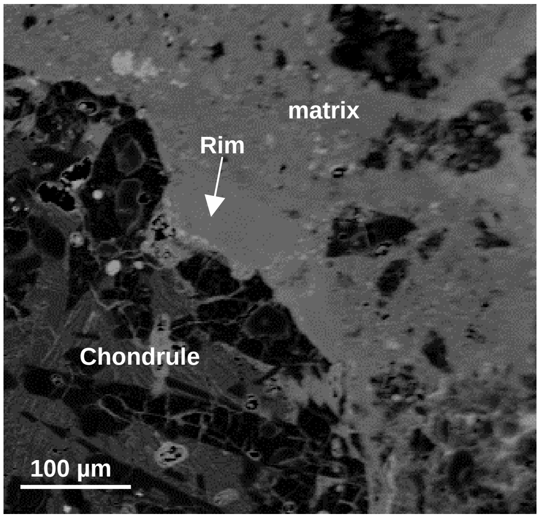

Figure 1. Backscatter electron image of chondrule, fine grained rim, and surrounding matrix. Note variable chondrule rim thickness.

Our preliminary data, averaged analyses from 4 matrix spots and 4 chondrule rim spots, are presented in Figure 2. This analysis indicates that chondrule FGRs and matrix in Vigarano have closely similar compositions.

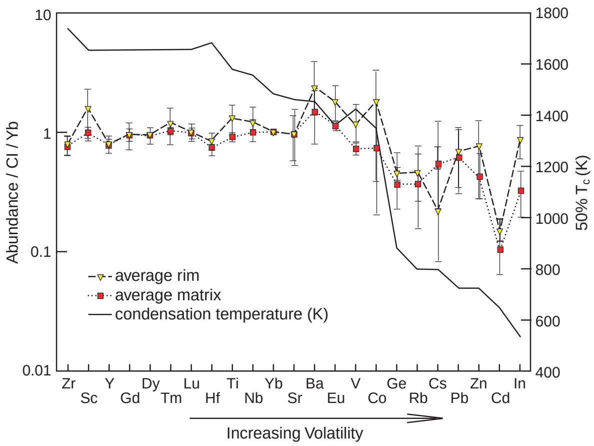

Figure 2. Trace element data (ordered in increasing volatility) for average matrix composition and average FGR material in Vigarano. Also plotted is condensation temperature (after [9]).

Discussion and Conclusions: The limited literature dataset on chondrule rim compositions [1-3,10] has offered no clear agreement on whether matrix is compositionally distinct from chondrule rims. Our initial analysis indicates that these components are very similar in composition. As with matrix compositions [4], rims are enriched relative to the bulk composition of their parent meteorites, but with a highly non-monotonic trace element pattern, which requires a complementary depletion in chondrule compositions to achieve a monotonic bulk. Rims apparently experienced similar processing to matrix, which plausibly occurred during chondrule formation. The chemical complementarity between fine grained materials in chondrites, and chondrules, suggests that these components formed in the same nebula region. Our data do not support the X-wind model, and appear most consistent with the shock-wave model for chondrule formation [11].

References: [1] Rubin A.E., Wasson J.T. (1987) *Geochim. Cosmochim. Acta, 51,* 1923-1937. [2] Kong P., Palme H. (1999) *Geochim. Cosmochim. Acta, 63,* 3673-3682. [3] Chizmadia L.J., Scott E.R.D, Krot A.N. (2005) *MAPS, 40,* A29. [4] Bland P.A. et al. (2005) *PNAS, 102,* 13755–13760. [5] Shu F.H., Shang H., Lee T. (1996) *Science, 271,* 1545-1552. [6] Günther D., Heinrich C.A. (1999) *J. of Anal. Atomic Spectrometry, 14,* 1363-1368. [7] van Achterbergh E., Ryan C.G., Jackson S.E., Griffin W.L. (2001) In: P. Sylvester (Editor), *Laser-ablation-ICPMS in the Earth Sciences: Principles and Applications*. Mineralogical Association of Canada, pp. 239-243. [8] Hathorne et al., (2004) *G3* No. 8408. [9] Lodders K. (2003) *Astrophysical Journal, 591,* 1220-1247. [10] Hua X., Zinner E.K., Buseck P.R. (1996) *Geochim. Cosmochim. Acta, 60,* 4265-4274. [11] Desch S.J., Connolly Jr. H.C. (2002) *Meteorit. Planet. Sci., 37,* 183-207.

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