USING REFRACTORY FORSTERITE GRAINS TO TEST MODELS OF ^{26}AL/^{27}AL HETEROGENEITY

T. Gregory[1,2], T. Luu[1], S. S. Russell[2], and T. Elliott[1]. [1]Bristol Isotope Group, School of Earth Sciences, University of Bristol, Bristol, BS8 1RJ, UK, timothy.gregory@bristol.ac.uk, [2]Natural History Museum, Department of Earth Sciences, Cromwell Road, SW7 5BD, London, UK

Introduction: Refractory forsterite (RF) grains are ubiquitous in unequilibrated chondrites of all classes [1,2]. They are characterised by their high forsterite content [3] ($Fo_{>\sim 98}$), enrichment in refractory lithophile elements Al, Ca, and Ti, and depletion in Ni and Mn [2]. They are also enriched in ^{16}O compared to "normal" olivine [4]. They come in three varieties: (i) isolated grains within matrix [5], (ii) the cores of some olivine phenocrysts in type-II (FeO-rich) chondrules [6], and (iii) phenocrysts in type-I (FeO-poor) chondrules [7]. All three types of RFs share strong similarities in their chemical and O-isotopic composition, so are probably genetically linked [8]. Models which explain the formation mechanism(s) of RFs include condensation [9], recycling of previous generations of chondrules [10], crystallisation from refractory condensated melts [11], and fragmentation of the silicate portion of differentiated planesesimals [12]. While their origin is uncertain, RFs are early Solar System solids.

Testing $^{26}Al/^{27}Al$ heterogeneity. The ^{26}Al-^{26}Mg short-lived chronometer ($t_{½}$ = 0.73 Ma) is widely used in understanding the duration and order of events in the early Solar System. It relies on the assumption that $(^{26}Al/^{27}Al)_0$ (initial $^{26}Al/^{27}Al$) was uniform across the protoplanetary disk. Such a "canonical" $(^{26}Al/^{27}Al)_0$ has been derived from CAI, the bulk data of Jacobsen et al. (2008) [13] yielding a popular reference value of $(5.23 \pm 0.13) \times 10^{-5}$ with an associated initial $\Delta'^{26}Mg$ (mass-independent variation of $^{26}Mg/^{24}Mg$) of -40 ± 29 ppm (Fig. 1). However, Larsen et al. (2011) [14] measured the Mg-isotopic composition of bulk-CAIs and -AOAs and reported an isochron with an intercept of $\Delta'^{26}Mg$ of -15.9 ± 1.4 ppm at Al/Mg = 0. This requires a lower $(^{26}Al/^{27}Al)_0$ of ~ 2.6×10^{-5} to evolve to present day bulk Solar System ($\Delta'^{26}Mg$ = 4.5 ± 1.0 ppm [14]) (Fig. 1). To explain this, Larsen et al. (2011) suggested initial $(^{26}Al/^{27}Al)_0$ heterogeneity across the protoplanetary disk.

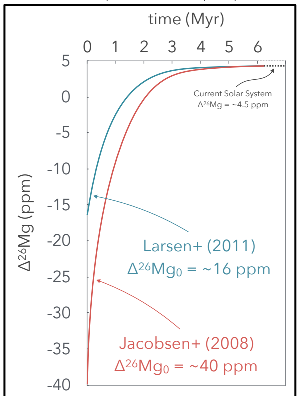

Fig. 1. $\Delta^{26}Mg$ evolution curves [13,14].

The Larsen et al. (2011) model predicts that no Solar System object will have a $\Delta'^{26}Mg$ of <-16 ppm. RFs provide a way in which this model can be tested. Their low-Al/Mg means that their present-day $\Delta'^{26}Mg$ reflects their initial $\Delta'^{26}Mg$, and their antiquity means that they may have formed early enough that the two $\Delta'^{26}Mg$ evolution curves (Fig. 1) had not yet converged.

Characterising RFs: We characterised 22 RFs in three unequilibrated chondrites: Northwest Africa (NWA) 8276 (L3.0), Felix (CO3.3), and NWA 4502 (CV3). Each grain was imaged at high magnification in both back-scattered electrons and X-ray energy dispersive spectroscopy, and their chemical compositions were measured using electron probe microanalysis. O-isotope analyses on each grain were performed at CRPG-CNRS (Nancy, France), as part of a Europlanet project, using secondary ionisation mass spectrometry.

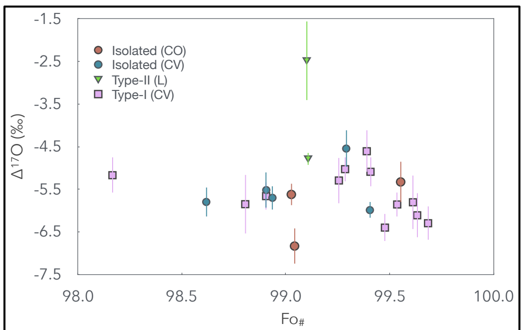

Fig. 2. The RFs that have been characterised.

We found no relationship between the O-isotopic and the chemical composition of RFs (Fig. 2), and no difference in chemical composition between RFs from different chondrite groups, in keeping with previous work. One RF in a type-II chondrule in NWA 8276 (L3.0) appears to be less ^{16}O-rich than those in COs and CVs, but this could be a result of our small sample size.

Future work. The $\Delta^{26}Mg$ of each will be measured to high precision (~±2 ppm, 2σ), after micro-drilling from their host section-and analysis via MC-ICP-MS. This work is ongoing.

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