SIZE OF THE GROUP IVA IRON METEORITE CORE: CONSTRAINTS FROM THE AGE AND COMPOSITION OF MUONIONALUSTA.

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Introduction: The group IVA fractionally crystallized iron meteorites display a diverse range of metallographic cooling rates, ranging from 100 - 6600 K/Myr [1,2]. These have been attributed to their formation in a metallic core, ~150 km in radius that cooled to crystallization without any appreciable insulating mantle. Such an exposed core may have resulted from a hit-and-run collision [3] between two large (~10^3 km) proto-planetary bodies. Here we build upon this formation scenario by incorporating several new constraints. These include (i) a recent U-Pb radiometric closure age of 4565.3 Mya (<2.5 Myr after CAIs) for the group IVA iron Muonionalusta [4], (ii) new measurements and modeling of highly siderophile element compositions for a suite of IVAs, and (iii) consideration of the thermal effects of heating by the decay of the short-lived radionuclide ^{60}Fe.

IVA Fractional Crystallization Model: We model the fractional crystallization sequence of the IVA system using an approach similar to [5]. With initial S, P, Re and Os compositions of 3%, 0.1%, 295 ppb and 3250 ppb respectively we find that compositions similar to Muonionalusta are produced after ~60% fractional crystallization. For an inwardly crystallizing core [6] this suggests formation at 70% the radius, R, of the body.

Thermal Conduction Model: To match the wide range of IVA cooling rates we follow [1] by assuming an exposed core that cools without any insulating silicate mantle. We solve the 1D thermal conduction equation [7] for cores with variable amounts of live ^{60}Fe, ranging from zero [8] up to a plausible maximum of ^{60}Fe/^{56}Fe = 4 x 10^{-7} [9]. With core size and ^{60}Fe abundance as the primary variables in this model, we fit both the range of IVA cooling rates and the crystallization of Muonionalusta at 4565.3 Myr at a radius of 0.7R.

Results: Our calculations suggest that the IVA core was 50-110 km in radius *after* the hit-and-run collision. This range is primarily due to uncertainties in the initial abundance of live ^{60}Fe incorporated into the IVA core. This emphasizes the need to better constrain initial ^{60}Fe abundances for the IVAs and other iron meteorite parent bodies that may have crystallized within a few half-lives of ^{60}Fe after CAIs ($\tau_{1/2}$=2.62 Myr). Candidates for such early formation include the IIAB, IIIAB and IVB groups. Lastly, our models define a relationship between cooling rate and closure age. For example, IVAs with the fastest cooling rates (>1000 K/Myr) may have absolute ages separated by as little as a few times 10^5 years after CAI formation. The details of this relationship can be firmly established if old U-Pb ages are confirmed/measured for Muonionalusta and other IVAs.

References: [1] Yang J., Goldstein J.I. and Scott E.R.D. 2007. *Nature* 446:888-891. [2] Yang J., Goldstein J.I. and Scott E.R.D. 2008. *Geochimica et Cosmochimica Acta* 72:3042-3061. [3] Asphaug E. et al. 2006. *Nature* 439:155-160. [4] Blichert-Toft J. et al. 2010. *Earth and Planetary Science Letters* 296:469-480. [5] Walker R.J. et al. 2008. *Geochimica et Cosmochimica Acta* 73:5189-5201. [6] Ruzicka A. and Hutson M. 2006. *Meteoritics and Planetary Science* 41:1959-1987. [7] Moskovitz N. and Gaidos E. 2011. *Meteoritics and Planetary Science*, in press. [8] Quitte G. et al. 2010. *Astrophysical Journal* 720:1215-1224. [9] Mishra R.K. et al. 2010. *Astrophysical Journal Letters* 714:L217-L221.