FRACTIONAL CRYSTALLIZATION MODELING OF CARBONACEOUS-TYPE IRON METEORITES.

Bidong Zhang[1], Nancy L. Chabot[2] and Alan E. Rubin[1], [1]Dept. Earth, Planet. Space Sciences, Univ. California, Los Angeles, CA 90095-1567, USA, [2]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA.

Introduction: Magmatic iron meteorites are the products of fractional crystallization in well-mixed asteroidal metallic cores. Based on their distinct isotopic compositions [1, 2], the 11 currently recognized magmatic iron groups have been divided into those associated with the carbonaceous reservoir (CC-type irons) in the outer Solar System and those associated with the non-carbonaceous reservoir (NC-type irons) in the inner Solar System [2]. Here we present comprehensive fractional-crystallization modeling of the CC-type groups (IIC, IID, IIF, IIIF, IVB) and the South Byron Trio (SBT) to reconstruct their crystallization processes and initial compositions and to compare CC-type asteroidal cores.

Experimental and Modeling Methods: We used the concentrations of 15 elements (Cr, Co, Cu, Ni, Ru, Sb, Pt, Ga, Ge, As, W, Re, Os, Ir, Au) in CC-type irons analyzed by INAA and/or RNAA at UCLA. Phosphorus concentrations are from [3]; other elements (Ru, Os, Pd, Rh, Mo) by LA-ICP-MS are from [4-8]. The fractional-crystallization modeling method follows [9] and uses the parameterization from [10]. Based on the element-As trends, we present preliminary modeling of all CC-type groups by simple fractional crystallization without considering trapped melt and with the initial assumption that the iron-meteorite trends sample the first solids that crystallized in the core.

IIC: Crystallization modeling for this group uses initial concentrations of 5.5 wt% S and 2.5 wt% P. Consistent with [7], our study shows that Wiley is now ungrouped due to its high Co, Ni and Ir. The eight remaining IIC members represent 0−33% crystallization products of the core, a slightly wider range than the 10−26% reported by [7]. The Ni- and CI-normalized initial composition of refractory siderophiles (RSE) (Re, Os, Ir) in the parent melt is ~1×CI.

IID: The fractional-crystallization model shows initial concentrations of 0.1 wt% S and 2.5 wt% P, similar to previous results (0.7 wt% S; 1.4 wt% P) [11]. High P in the initial metallic melt is consistent with ubiquitous schreibersite in IID irons. In a W-As diagram, the low-As samples form a “cloud” instead of following the model track. The current collection of IID irons represents 0−76% crystallization of the parent core, consistent with the range of 0−73% estimated by [11]. The Ni- and CI-chondrite-normalized initial composition of RSE in the IID parent melt is ~3×CI.

IIF: The element-As trends can be fitted with initial concentrations of 4.0 wt% S and 0.8 wt% P, except for the Co-As trend due to scattered Co. Our results contrast with 11−15 wt% S and 0.4 wt% P from [5], but their model does not fit all HSE with a single S content. In our study, the six IIF irons sample 0−72% crystallization of the core. The Ni- and CI-normalized initial composition of RSE in the parent melt is ~1.7×CI.

IIIF: We used 2.0 S wt% and 1.3 P wt% to model the group. The model works well for Re, Os, Ir and Pt, but Binya, Cerro del Inca, St. Genevieve County and Moonbi do not fit the Ga-As and Ge-As diagrams. The model does not adequately account for the wide range of Co concentrations (3.10-4.86 mg/g) in IIIF. We tentatively suggest that Binya, Cerro del Inca, St. Genevieve County and Moonbi are not from the same parent body as the other IIIF members.

IVB: Previous workers [4, 8, 9, 12] showed that the IVB parent melt had extremely low initial S and P. Similarly, our modeling indicates 0.01 wt% S and 0.8 wt% P for the initial melt. IVB irons sample 0−79% crystallization of the core, similar to the 17-86% crystallization range found by [4]. The Ni- and CI-normalized initial composition of RSEs in the IVB parent melt is 3×CI.

South Byron Trio (SBT): In our model, the SBT can be fitted with initial 8.0% S and 1.5% P, similar to the previous modeling-derived 7 wt% S and 1 wt% P [6]. Babb's Mill (Troost's Iron), South Byron and Inland Forts 83500 represent 1%, 8% and 35% crystallization of the core, respectively; the corresponding numbers in [6] are 1%, 2% and 42%. We agree with [6] that the elemental concentrations in the metal of the Milton pallasite do not fit the SBT crystallization model. The Ni- and CI-normalized initial composition of RSE in the SBT parent melt is ~1×CI.

Initial Comparison Conclusions: Except for the initial 8.0 wt% S of the SBT, the CC-type iron groups have considerably lower initial S contents (≤5.5 wt%) than NC-type groups IIAB (17 wt%) [9] and IIIAB (11.5 wt%) [13]. The Ni- and CI-normalized initial compositions of RSE in the CC-type iron cores decrease as the initial S contents increase. Our modeling shows that the current collection of iron meteorites samples a partial sequence of fractional-crystallization products for all CC-type groups.

References: [1] Kruijer T.S. et al. (2019) *Nat. Astron.* 4: 1-9. [2] Warren P.H. (2011) *EPSL* 311: 93-100. [3] Buchwald V.F. (1975) *Handbook of Iron Meteorites*. [4] Campbell A.J. and Humayun M. (2005) *GCA* 69: 4733-4744. [5] Hilton C.D. et al. (2020) *MPS* 55: 2570-2586. [6] Hilton C.D. et al. (2019) *GCA* 251: 217-228. [7] Tornabene H.A. et al. (2020) *GCA* 288: 36-50. [8] Walker R.J. et al. (2008) *GCA* 72: 2198-2216. [9] Chabot N.L. (2004) *GCA* 68: 3607-3618. [10] Chabot N.L. et al. (2017) *MPS* 52: 1133-1145. [11] Wasson J.T. and Huber H. (2006) *GCA* 70: 6153-6167. [12] Neumann W. et al. (2018) *JGR: Planets* 123: 421-444. [13] Ni P. et al. (2020) *Nat. Geosci.* 13: 611-615.