

THE CRYSTALLIZATION AND COOLING OF CAPE YORK, REVISITED.

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Introduction: Magmatic iron meteorites are interpreted to have formed via the fractional crystallization of molten asteroidal cores. Systematic variations of elements seen between members of all of these groups are broadly consistent with fractional crystallization models, with trace element abundances determined by the melts' evolving compositions, and esp. enrichment in incompatible elements like S [1, 2]. With over 300 members, IIIAB iron meteorites are the largest group of magmatic iron meteorites represented in collections. Most of these meteorites are relatively homogeneous, representing discrete moments when melt of a single composition crystallized. Cape York is a unique IIIAB iron meteorite that, possibly due to its large size (58 tonnes, as several masses), preserves a detectable chemical gradient between different masses, and across a single larger mass (Agpalilik, 20 tonnes). This gradient grossly follows a pattern we would expect from the progressive fractional crystallization of a pool of metallic melt ~140 meters across, with some nuances [3]. Past work has attempted to explain the observed compositional trends as the result of differing proportions of melt trapped within a progressively-crystallizing dendritic structure, and as the result of equilibration between larger blocks of solidified / disrupted core material and intruding late-stage melt [3, 4]. We paired high-precision INAA analyses with experimental data on elemental diffusion rates in analogous metals [5], with the goal of constraining diffusion's effects on the observed elemental gradients across Agpalilik and in Cape York.

Samples and experimental procedure: Data were obtained by instrumental neutron activation analysis (INAA). Samples of clean metal from Cape York were cut to 3 x 3 x 5 mm when possible; in a few cases, material from given positions in Agpalilik was limited, and samples were made by combining smaller cuts. Flux standards used were Coahuila, Filomena, and NSB809B. Newer data were compiled with older Wasson lab INAA data for available elements, to improve statistics. Matlab was used to model elemental diffusion, from rates derived from [5].

Results and discussion: Improvements in instrumentation and technique over the past 35 years have allowed for higher-precision measurements of trace elements, and we were able to obtain reproducible data for some elements not previously studied. Diffusion rates for some of these elements differ by one or more orders of magnitude over temperatures from 1400°C to 1200°C; some elements like Pt and Ir are relatively immobile, regardless of temperature, while Cu, Ge, and Ga become significantly diffusive over the same temperature range. For these latter elements, the early crystalline solids' diffusive exchange with the melt is significant and the rate of crystallization of the solid is an important compositional control. The smooth gradients observed in Ir and Pt across Agpalilik are not inconsistent with a dendritic / trapped melt model, but additional modeling will help to resolve the extent to which observed analytical trends across the mass and around residual melt pockets / troilite nodules are the direct result of fractional crystallization, and to what extent they are due to post-solidus diffusion. Additional data will be presented at the conference.

References: [1] Chabot, N. L. L., & Haack, H. 2006. Evolution of asteroidal cores. *MESS II*, 747–771. [2] Kracher, A., & Wasson, J. T. (1982). The role of S in the evolution of the parental cores of the iron meteorites. *Geochimica et Cosmochimica Acta*, 46(1976), 2419–2426. [3] Esbensen, K. H. 1988. Chemical and petrological studies in iron meteorites. PhD Thesis. ESS UCLA & Metallurgy, Univ. of Denmark. [4] Esbensen, K. H., Buchwald, V. F., Malvin, D. J., & Wasson, J. T. 1982. Systematic compositional variations in the Cape York iron meteorite. *GCA*, 46(10), 1913–1920. [5] Righter, K., Campbell, A. J., & Humayun, M. 2005. Diffusion of trace elements in FeNi metal: Application to zoned metal grains in chondrites. *GCA*, 69(12), 3145–3158.