COOLING RATES OF IVA AND IIIAB METEORITES

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Introduction: A major puzzle in iron meteorite research is why metallographic cooling rates (MCR) show wide ranges (factor of 60 in group IVA [1], factor of 6 in group IIIAB [2]) within fractionally crystallized (magmatic) iron-meteorite groups, and why MCR correlate with compositions. Possible answers are that essentially all the insulating silicates had been stripped from the metallic cores [3] or that there are effects associated with composition or impact histories that are not properly treated in the conversion of phase-composition data to MCR [4]. In an attempt to better assess relative cooling rates within these groups we developed a new method based on Co/Ni ratios in kamacite and taenite; our preliminary results indicate comparatively little variation in cooling rates within IVA and IIIAB.

Method: Our approach is based on the variation with temperature of the double ratio $(Co/Ni)\alpha/(Co/Ni)\gamma$ [5]. We call this ratio $R\alpha\gamma$; it ranges from ~3 at 1000 K to ~30 at 720 K. Thus, the lower the cooling rate, the higher the value of $R\alpha\gamma$.

Experimental: We used the MPIC NanoSIMS to determine Co in kamacite and taenite; the spatial resolution was about 0.5 μm and the sampling depth <0.1 μm. By measuring the ratio near the interface we focused on the low-temperature record and minimized the effects of factors that may have affected the systems at high temperatures in the $\alpha+\gamma$ field. Our pilot study consisted of IVA irons Bishop Canyon and Duchesne with MCR differing by a factor of 25 and IIIAB irons Haig and Cumpas with MCR differing by a factor of 4.5.

The IVA irons have similar $R\alpha\gamma$ values of 22-23 implying that they cooled at rates that differ by less than a factor of 3 (2σ). The $R\alpha\gamma$ in IIIAB Cumpas was similar (~21), but that in Haig was ~29 indicating that it cooled several times slower, in contrast to the Haig MCR which is 4.5× higher than that for Cumpas [2].

Discussion: To help assess the reason for the contrasting IIIAB cooling rates we reexamined the MCR results [2]; to help eliminate possible high-temperature effects we limited the comparison to narrow taenite lamellae (halfwidths between 4 and 10 μm). We discovered that the Haig data distribution is anomalous and Bella Roca partly anomalous and that the central Ni contents in the other 11 irons were unresolvable; irons differing in MCR by a factor of 6 showed the same central Ni contents implying identical cooling rates at low temperatures. We infer that the anomalous behavior of Haig in both studies reflects shock effects.

Summary: Our preliminary study using a new cooling rate method indicates no difference in cooling rates between two IVA irons with MCR differing by a factor of 25. Our results imply that the Haig IIIAB iron cooled more slowly than Cumpas, in contrast to MCR data showing Haig to have cooled 4× faster. We suggest that this reflects shock damage in Haig that created tiny fractures in the taenite. These results cast doubt on published cooling rates showing large variations in groups IVA and IIIAB.

References: .[2] Yang J., et al.. (2008) *GCA* **72**, 3043. [2] Yang J. and Goldstein J. (2006) *GCA* **70**, 3197. [3] Yang J., et al. (2007). *Nature* **446**, 888. [4] Wasson J., Matsunami Y., and Rubin A. (2006) *GCA* **70**, 3149. [5] Widge S. and Goldstein J. (1977) *Met. Trans.* **8A**, 309.