EVOLUTION OF DIFFERENTIATED ASTEROIDS AS INFERRED FROM COOLING RATES OF MAGMATIC IRON METEORITES.

J. Yang[1], J. I. Goldstein[1] and E. R. D. Scott[2]. [1]Dept. of Mechanical and Industrial Engineering, University of Massachusetts, Amherst, MA 01003, USA. jiyang@ecs.umass.edu. [2]Hawai´i Institute of Geophysics and Planetary, University of Hawai´i, Honolulu, Hawai´i 96822, USA.

Introduction: Magmatic iron meteorites are generally thought to come from metallic cores of differentiated parent bodies that cooled slowly inside silicate mantles. Our new cooling rate data are incompatible with this model and imply that some cores and mantles were separated before the Widmanstatten pattern formed.

Cooling Rates: The metallographic cooling rates for both the IIIAB and IVA magmatic iron groups are correlated with bulk Ni content in each group [1, 2]. For IVA irons, cooling rates increase from 90 to 7000 K/Myr with decreasing Ni. For IIIAB irons, the cooling rate variation is smaller, 60-340 K/Myr. Even allowing for variations in nucleation mechanism and temperature, the cooling rate ranges in IIIAB and IVA are inconsistent with cooling in a core surrounded by a silicate mantle.

Discussion: The cooling rates of irons from the core of an asteroid with a silicate mantle should be the same [3]. Our cooling rates for the IIIAB and IVA irons are incompatible with such a model. We argue that their parent bodies experienced impacts that removed almost all of their silicate mantles before kamacite formed. For IIIAB irons, the impact produced a metallic core covered by some remaining silicate or regolith. For IVA irons, the impact left little or no silicate on the metallic core. Our cooling rate and thermal modeling suggest that at the time of the mantle-stripping impact, the temperature of the metallic core was 850-1200°C, i.e., the core and mantle may both have been partly molten. As a result, the metal cores then cooled faster near the surface and much slower near the center of the cores. If iron meteorites came from bodies that formed at 1-2 AU and were scattered into the asteroid belt by planetary embryos [4], the primary IVA and IIIAB bodies could have had their silicate mantles removed by tidal effects and impacts with embryos [5]. The very early separation of mantle materials from metallic cores may be the reason for the “missing” olivine meteorites [4].

Conventional thermal models imply that iron meteorite parent bodies had diameters of 24-130 km [6] or 4-200 km [7], but we infer that the metallic core of the IVA irons was around 300 km across and comparable in size to 16 Psyche, the largest known M class asteroid, which is 260 km across.

Our model also implies that the IIIAB and IVA cores crystallized inwards [8] not outwards [9] so high-Ni irons formed at the center.

References: [1] Yang J. and Goldstein J.I. 2006, *GCA.* In press. [2] Yang J. et al. 2006. *GCA*. To be submitted. [3] Haack H. et al. 1990. *JGR.* 95B:5111-5124. [4] Bottke et al. 2006. *Nature*. 439:821-824. [5] Asphaug E. et al. 2006. *Nature*. 439:155-160. [6] Haack H. and McCoy T. J. 2003. in *Meteorites, Comets and Planets*. Ed. by A.M. Davis. *Treatise on Geochemistry*. Vol.1. Elsevier, Amsterdam. 325-346. [7] Chabot N. L. and Haack H. 2006. in *Meteorites and the Early Solar System II.* In press. [8] Haack H and Scott E.R.D. 1992. *JGR.* 97:14727-14734. [9] Wasson J. T. 1985. *Meteorites: Their Record of Early Solar System History*. W.H. Freeman Press, New York.