CUMULATIVE IMPACT HEATING OF PLANETESIMALS

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Introduction: Impacts between porous planetesimals with velocities high enough to generate a shock wave may have contributed to the heating of meteorite parent bodies [e.g. 1, 2, 3, 4]. Numerical modeling has quantified the effects of initial conditions (porosity and temperature), relative body size, and relative collision velocity on heating during planetesimal collisions [5]. For impacts with a small impactor-to-target mass ratio ($M_i < 0.1M_t$), heating is local to the impact site. For larger impactors ($M_i > 0.1M_t$), heating on a global scale is possible, but in this case the impact disrupts the parent body.

Method: We quantify the cumulative impact heating on a parent body in the first 10 Myrs of Solar System evolution. Using the results of hydrocode simulations of heating in individual planetesimal collisions [5], we calculate the mass of material heated and the peak temperature reached throughout a target body when a population of impactors strikes its surface. Targets are followed until 10 Myrs of model time elapses or the parent body is disrupted. We use the disruption criteria of Jutzi et al. [6] with velocity scaling from Holsapple [7] to determine when a catastrophic collision occurs. The velocity- and size-frequency distributions of impactors evolve through time, according to the results of N-body planetesimal collisional evolution simulations [8]. The average (and extremes) of many thousands of model iterations are then calculated to examine the possible and most likely outcomes of cumulative impact heating for meteorite parent bodies.

Results: Assuming an initial planetesimal population of one thousand times the mass of the present day asteroid belt, approximately 14% of parent bodies are disrupted in 10 Myrs. In four out of every five of these disruptive collisions, at least 10% of the disrupted body is heated to the solidus. Of those parent bodies not disrupted in the first 10 million years, half will experience at least 1% of their mass heated to the solidus. The majority of this heating is done during a few large impacts close to the disruption threshold.

Conclusions: Since the majority of heating is achieved during several large sub-catastrophic to catastrophic collisions, the amount of heat generation is strongly dependant on the disruption criteria and the probability of a large impactor colliding with the parent body. The location of the heated material after such an impact is key to understanding parent body thermal evolution. To investigate this further, we will present detailed hydrocode modeling of the heating during these significant events.

References: [1] J.T. Wasson, et al. 1987. *Meteoritics*, 22:525–526, [2] A.G.W. Cameron, et al. 1990. *Lunar & Planet. Sci. Conf.*, 21:155–156, [3] A.E. Rubin. 1995. *Icarus*, 113:156–167, [4] J.T. Wasson and G.W. Kallemeyn. 2002. *Geochimica et Cosmochimica Atca*, 66:2445–2473 [5] T.M. Davison et al. 2010. *Icarus*, In Press. [6] M. Jutzi, et al. 2010. *Icarus*, 207:54–65. [7] K.A. Holsapple, 1993. *Ann. Rev. Earth Planet. Sci.* 21:333–373. [8] D.P. O'Brien, et al. 2006. *Icarus*, 184:39–58.