THE PLANETESIMAL SHOCK MODEL FOR CHONDRULE FORMATION: A MORE QUANTITATIVE ASSESSMENT.

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Introduction: Gas dynamic shock waves in a low-temperature nebula are currently considered to be a plausible mechanism for providing the repetitive transient heating events that were apparently responsible for chondrule formation (e.g., [1]). Possible meteoritic constraints on the sources of chondrule-forming shocks include: (1) isotopic evidence that chondrule formation most probably began 1-1.5 Myr after the formation of CAIs and continued for several Myr; (2) coexistence of chondrules in chondrites with products of later parent-body processes (e.g., igneous rock fragments); and (3) inferences that chondrule formation regions were large (more than several hundred km across) but also relatively localized to explain observed differences in properties of chondrules from different chondrite groups.

One class of nebular shocks that can potentially satisfy the above constraints is shocks generated by planetesimals passing through Jovian resonances, assuming that Jupiter formed ~ 1 Myr after CAIs [2,3,4]. Included are both planetesimal bow shocks produced by bodies ejected into eccentric orbits and impact vapor plume shocks produced by high-velocity collisions between planetesimals. Here, we employ an improved planetesimal accretion and orbital evolution code that includes the damping effects of collisions and mutual gravitational scattering between embryos. The goal is to provide more accurate estimates of potential chondrule formation efficiency by both planetesimal shock mechanisms.

Planetesimal Evolution Code and Results: A population of several hundred discrete bodies with diameters between ~750 and 2000 km and a total mass of ~ 1 Earth mass is initially distributed in 20 radial zones from 2 to 4 AU. In addition, a background population of smaller bodies is represented in the model by a statistical continuum. A symplectic N-body integrator is applied to calculate the orbital evolution of the large bodies. The accretion rate of discrete bodies is tracked and is used to estimate the collision rate with smaller bodies. After integration times of 250 kyr or more, only ~ 1% of the discrete bodies have $e > 0.3$ (corresponding to midplane crossing velocities $v_m > 5$ km/s). A few bodies rarely reach $e > 0.4$ ($v_m > 7.5$ km/s). The total cumulative area of the midplane that would be traversed by these bodies and their associated bow shocks over a period of several Myr is < 1% of the total area. The code output shows that bodies with $e > 0.2$ and diameters of 1000 – 3000 km typically gained mass at rates of $10^{16} – 10^{17}$ g/yr during the interval from 200 to 250 kyr. The corresponding impact interval for 1 km sized bodies (mass ~ 10^{15} g) is days to weeks. Implications of these results for chondrule formation efficiency in planetesimal-generated shocks will be presented at the conference.

References: [1] Desch S. J. et al. 2005. In *Chondrites & the Protoplanetary Disk,* A.N. Krot et al., eds., Ast. Soc. Pacific Conf. series, vol. 341. 849-872. [2] Hood L. L. 1998. *Meteoritics & Planetary Science* 33:97-107. [3] Weidenschilling S. J. et al. 1998. *Science,* 279:681-684. [4] Hood, L. L. et al. 2009. *Meteoritics & Planetary Science,* 44:327-342.