THE EARLY IMPACT HISTORIES OF METEORITE PARENT BODIES. T. M. Davison[1,2], D. P. O'Brien[3],

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Introduction: The early Solar System was a violent place for young planetesimals. Collisions with other planetesimals were common, and would have affected the evolution of the bodies that would go on to become asteroids and meteorite parent bodies. As meteorites provide our strongest evidence of conditions in the early Solar System, a full understanding of the histories of their parent bodies is vital.

Methods: A large number of planetesimals would have been present in the early Solar System, each with their own collisional history determined by a series of chance encounters with other planetesimals, and depend on the number, sizes and timing of the collision events. Therefore the impact history of a parent body through time cannot be solved analytically.

In this Monte Carlo model, the impact histories of many thousands of meteorite parent bodies are simulated: Collisions are allowed to occur on the surface until either the body is disrupted, or 100 Myr of model time has elapsed. The frequency, impactor size and velocity of the impacts are chosen based on simulations of the dynamical and collisional evolution of a population of planetesimals and planetary embryos during planet formation [1, 2, 3]. Two dynamical models were used: one with Jupiter and Saturn on orbits with their current inclination and eccentricity ('EJS') and one with the giant planets on near-circular, co-planar orbits, similar to that in the Nice model ('CJS'). The collateral effects of each collision are determined based on the impact parameters: crater sizes can be determined from crater scaling laws (e.g. [4], and references therein); impact heating [5] and disruption [6] can be estimated using shock physics calculations.

Results: Parent bodies were separated into two categories: those that were catastrophically disrupted within the first 100 Myr, and those that survived 100 Myr without a disruptive impact. For a 100 km radius parent body in the CJS model, on average 7.6% of bodies were disrupted within the first 100 Myr. For those bodies that were not disrupted, ~ 850 collisions with impactors > 150 m in radius were predicted by the model. On average, there was one collision per parent body of impactors > 5 km in radius, and one in five parent bodies would have experienced a collision with an impactor > 10 km in radius.

Both the number of impacts and the specific internal energy increase due to impacts show that the first ~ 10–20 Myr is the most important time for impact heating: the same period that radiogenic heating from short-lived radionuclides (e.g. [26]Al) was important.

Discussion: A model for the formation of the CV chondrite parent body [7] to account for the unidirectional magnetic field requires that a parent body of ~ 100 – 300 km radius accreted a crust of ~ 6 – 20 km thickness during heating by [26]Al. The interior of the body differentiated, and the surviving, undifferentiated crust was the source of the pristine CV chondrites. The crust must have have remained undisturbed while the parent body was being heated and the magnetic field was in place (~ 10 Myr), to prevent foundering.

In the Monte Carlo model, for 100 km radius parent bodies ~ 5 collisions per parent body penetrated to 6 km. Around one in four parent bodies experienced an impact that penetrated to 20 km. While less than 1% of 100 km radius parent bodies survived the first 10 Myr without a collision penetrating to 6 km, around 80% survived without a collision that penetrated to 20 km. For 250 km parent bodies, more collisions can be expected: ~ 23 collisions per parent body penetrated to 6 km, and each parent body experienced ~ 1 collision that penetrated to 20 km. No 250 km radius parent bodies survived 10 Myr without a collision that penetrated to 6 km, and ~ 40% of bodies survived without a collision that penetrated to 20 km. Therefore, it seems unlikely that the CV parent body could have developed in the way proposed by [7] if the crust was ≤ 6 km thick; our Monte Carlo model predicts that for the CV chondrite model to work, a thicker crust was required. If a 20 km crust was present, around 30 parent bodies of 100 km radius and one body of 250 km radius that matched the CV chondrite criteria would have survived to 100 Myr and remained in the asteroid belt.

We will use the model to further constrain the thermal and impact histories of the H chondrite, CB chondrite and IAB/winonaite parent body.

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