COLLISION VELOCITIES IN THE ASTEROID BELT: IMPLICATIONS FOR MELT PRODUCTION ON METEORITE PARENT BODIES

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The mean collision velocity among asteroids in the main belt is on the order of 5 km/s [1,2], which is close to the threshold impact velocity at which melt production begins to occur [3]. However, the distribution of impact velocities for the population as a whole, as well as onto a single asteroid, follows a roughly Maxwellian distribution, such that some impacts significantly above the mean velocity are likely to occur [1,2]. While such impacts are not likely to lead to large-scale melting of the target asteroid, or global heating comparable to that produced by radioactive decay [3], impacts at the high end of the velocity distribution may lead to localized heating and the production of impact melt breccias. Melt breccias are found in varying amounts in many classes of meteorites [4]. The impact velocity distribution can vary significantly among asteroids, such that some bodies are more likely to experience high-velocity, melt-producing impacts than others. This may have important implications for the evolution of meteorite parent bodies, and the differences between meteorite types found on Earth.

As an example of the differences between specific asteroids, consider Hebe, a possible parent body of the H chondrites [5], and Flora, which some evidence suggests could be the parent body of the L chondrites [6]. Using the algorithms of [1] and [2], we performed preliminary calculations of the velocity distribution of impacts onto these asteroids. For the impacting population, we included all asteroids larger than 50 km in diameter, using the osculating (instantaneous) orbital elements from the JPL database [7]. While nearly all impactors will be smaller than this, the population of bodies larger than 50 km in diameter is sufficient to give a relatively unbiased estimate of the orbital distribution of asteroids. For the target asteroids, we use the proper orbital elements of [8], which better represent the long-term average behavior of the asteroids. These calculations are only valid since the time of the Late Heavy Bombardment, before which the asteroids may have been on different orbits.

Based on their current (post-LHB) orbits, Hebe has a mean impact velocity larger than the main-belt average, while Flora's value is below the main-belt average. We find that roughly 65% of impacts onto Hebe occur at velocities larger than 5 km/s, while for Flora that value is only about 35%. Roughly 18% of impacts onto Hebe occur at velocities larger than 8 km/s, while for Flora that value is only about 6%.

Based on this, one might expect that the relative abundance of post-LHB impact melt breccias among the different meteorite types could reflect the orbital characteristics of their parent bodies. Other factors may come into play, however, including the relative importance of stochastic large impacts vs. more frequent smaller impacts, the details of the meteorite ejection and delivery process, and parent-body material properties. We will discuss these issues in light of the meteoritic evidence.

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