QUANTIFYING HEATING IN POROUS PLANETESIMAL COLLISIONS. T.M. Davison¹, G.S. Collins¹ and F. Ciesla².
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Introduction: Collisions between planetesimals at speeds of several kilometers per second were common during the early evolution of our Solar System [e.g. 1,2,3,4]. However, shock heating of planetesimals in such impacts has largely been dismissed as a substantial heat source because of the high impact velocity required to shock-heat significant volumes of non-porous rock [e.g. 5,6]. However, recent experimental and numerical work suggests that the low velocities at which dust aggregation occurs will result in highly porous (> 65 % pore space by volume) planetesimals [7,8,9]. It is well-known that the presence of porosity can dramatically increase the amount of heating in an impact due to the large amount of energy expended crushing out the pore-space [e.g. 10,11]. In this work, we quantify the efficiency of heating during high velocity collisions between planetesimals using hydrocode modeling. In an ongoing series of simulations, we test the effect on shock heating of the initial porosity and temperature of the planetesimals, the relative velocity of the collision, the relative size of the two colliding bodies, and temperature and porosity heterogeneities within the colliding bodies.

Results: Our results show that while heating is minor in collisions between non-porous planetesimals at impact velocities below 10 km/s, much higher temperatures are reached in collisions between porous planetesimals. As a result, substantial melting of nearly equal-sized bodies can be achieved at collision velocities below 7 km/s, depending on initial porosity and temperature. For initially warm bodies (~ 700 K), a collision velocity of ~ 5 km/s is sufficient to produce a substantial mass of melt. Such collisions would catastrophically disrupt the two bodies. For collisions of small bodies into larger ones, such as those with an impactor-to-target planetesimal mass ratio below 0.1, significant localized heating occurs in the target body. At an impact velocity of 5 km/s, the mass of melt produced is about twice the impactor mass, a mass of up to four times the impactor mass is heated by 400K, and temperature increases of 100 K occur in a region up to 10 times the impactor mass. In such collisions the majority of the impactor is also shock-heated above the melting point. Hence, energetic collisions between planetesimals in the early solar system may have resulted in the heating of significant volumes of primitive materials [12].