IMPACT MELT ON ASTEROIDS: NEW INSIGHTS FROM ONE-DIMENSIONAL SIMULATIONS.

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Introduction: The following work provides a new perspective on asteroid evolution through a computational modeling study of impact melt. Some authors assert that impacts are not significant sources of heating and melting on asteroids [1]; yet those authors do not consider the importance of porosity or strength in their computational models. Davison et al. [2] perform a robust study to determine the significant effects of porosity on the impact process and thermal evolution of a planetesimal-sized body. They show that impacts can heat regions of the body to temperatures that induce petrologic changes seen in meteorites. On the basis of shear experiments, others argue that low-speed impacts can create localized friction-induced melting along fracture zones under low peak pressures [3]. The work presented here is a preliminary, complementary study that considers the role of strength in impact-melt generation. We conclude that impacts may indeed be responsible for some of the metamorphism or melting observed in meteoritic materials [2, 4-6].

Methods: A one-dimensional study was performed with the shock physics code CTH [7] in which a flyer plate impacts a target composed of the same material at impact velocities from 5 to 10 km/s, the lower end of which is applicable to asteroids. Materials studied include basalt, dunite, water ice, and iron. Pressure, temperature, and entropy were recorded throughout the impact process. Both a hydrodynamic impact calculation and one including an appropriate material strength model were performed for each material and impact velocity.

Results: The hydrodynamic calculation for each material established a reference for the calculations that include material strength. Pressure vs. entropy and pressure vs. temperature were plotted for each calculation. The effects of strength in each material become negligible at impact velocities above 10 km/s, i.e. pressure, temperature, and entropy behave similarly to the hydrodynamic case. However, for calculations using a strength model appropriate for geologic materials, and at velocities below 10 km/s, the results indicate that peak pressure decreases, while final entropy of the system increases and final release-state temperature increases.

Discussion: Because our results show that entropy and final release-state temperature are elevated from the hydrodynamic case in low-velocity impacts, there is a possibility that strength effects may lead to melting and petrologic changes on asteroids. Some models neglect to account for strength or porosity, but these factors, in addition to localized shear heating, do play an important role in heat and melt generation [2, 3]. Both strength and porosity are present on asteroids; hence, the potential for impact melt on asteroids should not be ignored.

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