AFFECT OF CORE RHEOLOGY ON SHOCK WAVE PROPAGATION IN PLANETARY SCALE IMPACTS.

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Introduction: Large impacts forming basin-sized structures on planetary surfaces generate shock waves that may be strong enough to deliver a significant amount of heat to the planetary interior. Planets and moons as well as large asteroids such as Vesta or Lutetia are thought to be differentiated into a silicate mantle and an iron core. How the heat budget of the interior of these bodies was affected by impact processes may depend on the thermodynamic state and, thus, the internal rheology during their thermal evolution.

We conduct a suite of iSALE [1-3] hydrocode models of large impacts on planetary-size target to investigate the effect of the thermal conditions and rheology of the target on the propagation of shock waves. In particular we focus on the effect of a liquid or solidified core on shock wave decay.

Shock decay in a planetary core: Figure 1 shows the shock decay in the target body after an impact of a 184 km-radius dunitic projectile at 10 km/s. The target planet has a radius of 3450 km and consists of a dunitic mantle and an iron core with a radius of 1725 km. Comparing the three different cases there are almost no differences in the shock pressure decay in the mantle up to a depth of 0.5 target planet radii which corresponds to the depth of the core mantle boundary (CMB) in the given model. Small deviations between the three different cases are due to small differences of the thermal gradients in the mantle. Below the CMB the three cases show significant differences. If an iron core is present (green and blue) there is a kink in the pressure decay caused by the impedance contrast between the core and the mantle. Inside the core the shock pressure decays much faster in case of the solid core (green) that has some strength *Y* in comparison to the liquid core (blue) that behaves hydrodynamically with no mechanical resistance against deformation. In the latter case the shock pressure is up to 3 times higher than for the solid core.

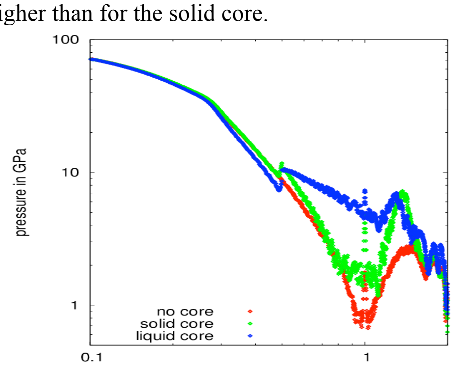

Fig 1. Peak shock pressures reached in the target planet, measured along the symmetry axis. Impactor radius of 184 km and velocity of 10 km/s. The target is a spherical dunitic body with a radius of 3450 km with no core (red), a solid core (green) and a liquid core (blue).

Planar impact models: To investigate the principle reason for the effect of strength on pressure decay we conducted planar shock wave propagation models assuming the rheology of liquid (strengthless) and solid (strength) material. For simplicity we use a constant strength of *Y*=1 GPa and neglect thermal softening or the dependency of strength on confining pressure and the deformation history (damage). The results (fig. 2) confirm that the shock pressure decays faster in the case with strength compared to the hydrodynamic case (strengthless). In our models the hydrodynamic material is unloaded to zero pressure while the material with strength maintains a pressure of the order of the given strength of 1 GPa. Complete unloading takes place at some later time. The incomplete unloading after shock wave release results in a slightly increased density and speed of sound of the material giving rise to a faster propagation of the rarefaction wave and, thus, faster attenuation of the shock wave.

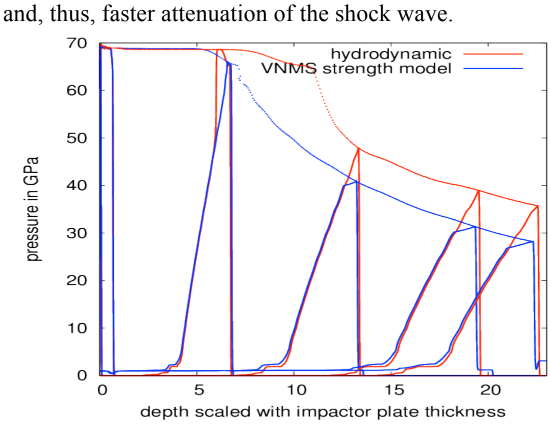

Fig 2. Shape of the shock wave in a planar impact model with an impact velocity of 5 km/s at different times. The dotted lines represent the peak pressure for each time step.

Conclusion: The rheology of the target body significantly affects the propagation and decay of a shock wave. If the target material has some strength the shock wave decays more rapidly than in the hydrodynamic case where no strength is present. This holds true even if the material is significantly weakend due to the accumulation of damage and its rheology is more like the one of granular matter. Consequently, a completely solidified iron core experiences significantly lower shock pressures than a liquid core after impact of an equally sized body.

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References: [1]Amsden A.A. et al. *Los Alamos National Laboratories Report*, LA-8095:101p, (1980). [2] Ivanov B.A. et al., (1997), *Int. J. Impact Eng.* 17, 375–386. [3]Wünnemann K. et. al. (2006), *Icarus*180