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Impact-induced Melting by Giant Impact Events.

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Large impact events have influenced the chemical and thermal evolution of the terrestrial planets [1]. The collision of a giant cosmic body with a proto-planet adds and/or removes material and heats up the interior of the target planet, but also shapes planetary landscapes (crater structures, ejecta blankets, magma ponds and oceans). To quantify the amount of melt generated by such impacts, so-called scaling laws based on theoretical considerations and numerical modelling enable to estimate the melt volumes as a function of the impact velocity and the size of the impactos. We find, that such classical scaling laws [2] predict the amount of shock melting for events roughly smaller than basin forming impacts reasonable well, but they fail to estimate the melt volume for giant impact events.

To quantify the impact-induced melt production, we use the iSALE shock physics code [3] combined with ANEOS [4], an equation of state, for mantel (dunite), core (iron) and crustal material (basalt for Mars).
To determine the distribution and volume of impact-induced melting we calculate the local (post-impact) final temperature T_f via the peak shock pressure method and compare it with the solidus (or liqidus) as a function of lithostatic pressure [5]. Therefor we use Lagrangian tracers to record the materials highest shock pressure P_peak (peak shock pressure) it experiences and use ANEOS to calculate its final temperature in equilibrium state. As tracers also track the movement of the material, this approach allows for taking decompression melting into account. In our models we assume typical individual conditions for our target planets regarding gravity, impact velocities or initial temperature gradients [6]. Target curvature is taken into account for very large impact events. In all our models the projectile radius is resolved by 50 cells per radius.

We find, that our models are approximately in agreement with classic scaling for smaller impacts; however, larger impacts significantly deviate. We find that if the impactor size is in excess of a certain threshold diameter, the shock-induced normalized melt production (Vmelt /Vprojectile) is more or less significantly increased. This depends on the initial temperature T_i reflecting the evolutionary state of the planet. The increase in melt production results from the fact that for a “warm” planetary interior less shock heating (ΔT_M) is required to induce melting than for a planet, where the temperature difference between T_S (solidus) and T_i as a function of depth is larger. It can be shown that the maximum normalized melt production occurs at an impactor size, where the main melt body is located in a depth where the smallest amount of ΔT_M is required to cause melting (where the temperature profile approaches the solidus). This area is often located close to the bottom of the lithosphere.

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References:[1]Marchi,S.et_al.(2014),Nature511. [2]Bjorkman,M.D._and_Holsapple,K.A.(1987),Int.J.ImpactEng.5. [3]Collins.G.S.et_al.(2004),M&PS.39. [4]Melosh,H.J.(2007),M&PS42. [5] Ruedas,T._and_Breuer,D.(2017),JGR,122. [6]Plesa,A.-C.et al.(2016),JGR,121.