IMPACT CRATERING: SCALING FROM LOW VELOCITIES TO HIGH VELOCITIES.

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The formation of impact craters on planetary surfaces, as well as the fate of the impactor's material are of major interest in planetary sciences and deep-Earth geophysics. Scaling-laws for the crater size as a function of impact parameters have been derived from laboratory experiments or numerical simulations (e.g. [1], [2], [3], [4]). Most of these focus on granular material or on small impacts that do not produce large magma oceans on the impacted surface. Here, we investigate the case of large impacts onto magma oceans during which the fate of the impactor's material is particularly important for the Earth. The mixing of the impactor's core into Earth's mantle controls the chemical equilibration between metal and silicates, and hence the composition of Earth's core and Earth's mantle. However, the mixing is poorly constrained in numerical simulations, leading to the development of laboratory experiments of water drop impacts that allow for a better description of the turbulence and the mixing of the impactor's material. Yet, laboratory experiments cannot reach the supersonic conditions of large planetary impacts. Here, we first compare laboratory experiments with numerical simulations (with the iSALE shock physics code [5, 6, 7]) for subsonic impact speeds to test whether numerical simulations reproduce the laboratory experiments for water. We then increase the impact velocity by small increments until reaching realistic supersonic values. We obtain scaling laws for the crater depth as a function of the Froude number (the ratio of inertia to gravity) and the Mach number (the impact-to-sound velocity). These scaling laws describe well the transition from low-velocity subsonic impacts to supersonic speeds. Different material types (i.e. different equations of state) are tested: water, aluminium, basalt and ice. All materials depict the same trend regarding the maximum crater depth as a function of the Mach number. This strongly highlights the importance of considering the velocity as a string parameter for understanding crater formation.

References:

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