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Experimental insights of liquid impacts onto granular beds of various packings : The packing influence over the excavated volumes

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Most of the past studies focused on solid impacts onto granular beds addressing key questions such as the crater dimensions or the impactor deceleration. Recent investigations were oriented toward the more complex case of liquid-to-granular impacts. However, the influence of the packing over the impact process and the bed response is not clearly understood. Moreover, we may assume the general scaling law which relates the average crater volume to the kinetic energy is invariant regarding the impact type (solid-to-granular, liquid-to-granular). Hence, we address the influence of the granular bed packing over both the excavated & deposited volumes.
We propose to study liquid-to-granular impacts via an experimental protocol, which is described in the following. A device releases 2.34±0.14 mm radii water droplets, which vertically fall from different heights (50, 100, 200 & 290 mm) onto fine granular samples (d50 = 0.0357 mm) of diameter 400 mm. Each granular sample was previously compacted using a heavy circular plate and a shaking device. Pre and post-impacts geometries are acquired using a 3D scanner, which is the KONICA MINOLTA VIVID 9i fitted with a TELE lens 25 mm with a focal distance of 25 mm and a theoretical vertical precision of 0.008 mm with a standard deviation of 0.024 mm. High density 3D point clouds result from this experimental procedure. Spatial changes are then characterized and provide a quantification of excavated & deposited volumes or local granular bed uplifts.
We observe a common pattern for every impacts: the local granular bed uplift at the periphery of the impact center. This shows the difficulty to distinguish deposited materials from uplifted materials. Achieving distinction between deposition and uplift process leads to an average uplift-induced volume proportion of 0.94-0.97 (i.e. the ratio between deposited volume and uplift-induced volume), which illustrates the high dissipation of energy
The granular bed packing influence is clearly visible, even though the packing is not the only factor that govern the bed response during liquid-to-granular impacts. An exponential statistical relationship is able to fit quite well the data but shows regarding the values of R^2 (ranging from 0.63 to 0.78) for different impact energy.
The average excavated volume is strongly related to the average impact energy, as previously mentioned by Deboeuf et al. (2009) of solid-to-granular impacts. The power scaling law which were used by Deboeuf et al. (2009) is in good agreement with the volumes we measured. This suggest similarities between impact types (liquid-to-granular and solid-to-granular) and strengthens the similarities observed between asteroid strikes and liquid-to-granular impacts, as mentioned by Zhao et al. (2015).
Our work clearly highlights the influence of the granular packing over the process. High definition 3D acquisitions acknowledge evidences of granular bed uplifts. Furthermore, these results unravel expected similarities between solid and liquid impacts onto a granular medium. A strong numerical model is the next step toward a more accurate understanding of liquid-to-granular impacts, especially to understand the relative importance of unitary ejection, local bed compression and uplift throughout the impact process.