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Fluid mechanical scaling of impact craters in unconsolidated granular materials COLIN S. MIRANDA, DAVID R. DOWLING, Dept. of Mech. Eng., Univ. of Mich., Ann Arbor MI 48109 — A single scaling law is proposed for the diameter of simple low- and high-speed impact craters in unconsolidated granular materials where spall is not apparent. The scaling law is based on the assumption that gravity- and shock-wave effects set crater size, and is formulated in terms of a dimensionless crater diameter, and an empirical combination of Froude and Mach numbers. The scaling law involves the kinetic energy and speed of the impactor, the acceleration of gravity, and the density and speed of sound in the target material. The size of the impactor enters the formulation but divides out of the final empirical result. The scaling law achieves a 98% correlation with available measurements from drop tests, ballistic tests, missile impacts, and centrifugally-enhanced gravity impacts for a variety of target materials (sand, alluvium, granulated sugar, and expanded perlite). The available measurements cover more than 10 orders of magnitude in impact energy. For subsonic and supersonic impacts, the crater diameter is found to scale with the 1/4- and 1/6-power, respectively, of the impactor kinetic energy with the exponent crossover occurring near a Mach number of unity. The final empirical formula provides insight into how impact energy partitioning depends on Mach number.

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