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Experimental impact crater morphology

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The research group MEMIN (Multidisciplinary Experimental and Impact Modelling Research Network) is conducting impact experiments into porous sandstones, examining, among other parameters, the influence of target pore-space saturation with water, and projectile velocity, density and mass, on the cratering process. The high-velocity (2.5-7.8 km/s) impact experiments were carried out at the two-stage light-gas gun facilities of the Fraunhofer Institute EMI (Germany) using steel, iron meteorite (Campo del Cielo IAB), and aluminium projectiles with Seeberg Sandstone as targets. The primary objectives of this study within MEMIN are to provide detailed morphometric data of the experimental craters, and to identify trends and characteristics specific to a given impact parameter. Generally, all craters, regardless of impact conditions, have an inner depression within a highly fragile, white-coloured centre, an outer spallation (i.e. tensile failure) zone, and areas of arrested spallation (i.e. spall fragments that were not completely dislodged from the target) at the crater rim. Within this general morphological framework, distinct trends and differences in crater dimensions and morphological characteristics are identified. With increasing impact velocity, the volume of craters in dry targets increases by a factor of $\sim$4 when doubling velocity. At identical impact conditions (steel projectiles, $\sim$5km/s), craters in dry and wet sandstone targets differ significantly in that “wet” craters are up to 76% larger in volume, have depth-diameter ratios generally below 0.19 (whereas dry craters are almost consistently above this value) at significantly larger diameters, and their spallation zone morphologies show very different characteristics. In dry craters, the spall zone surfaces dip evenly at 10-20° towards the crater centre. In wet craters, on the other hand, they consist of slightly convex slopes of 10-35° adjacent to the inner depression, and of sub-horizontal tensile failure planes (“terraces”) in the outer, near-surface region of the crater. We suggest that these differences are due to a reduction in tensile strength in pore-space saturated sandstone. Linking morphological characteristics to impact conditions might provide a tool to help reconstruct impact conditions in small, more strength- than gravity-dominated impact craters in nature. Findings in small-scale experiments can aid the identification of particular structures in the field, such as spallation induced uplift of strata outside of the crater margins.