THE EFFECTS OF PROJECTILE SIZE ON CRATER FORMATION AND SPALLATION IN EXPERIMENTAL IMPACT CRATERING.

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Introduction: With the advance of increasingly high resolution remote sensing missions, small impact craters on planetary surfaces and other solid bodies can be observed at increasingly high detail on the meter scale and even below. At this size, target material properties play a dominant role in the formation and final shape of these craters. Experimental data help to improve the understanding of how these target material properties influence small-scale cratering, and which implications they can have for planetary processes.

Impact cratering experiments were performed on quartzite, tuff, and dry and water-saturated sandstones in the framework of the MEMIN research unit [1,2]. 2.5 to 12 mm diameter steel and iron meteorite projectiles were accelerated to ~5 km/s at the two-stage light-gas gun facilities of the Fraunhofer EMI. Evaluation of the resulting craters shows that crater volumes and crater efficiencies of large-scale experiments are greater than predicted by strength scaling laws.

An improved method to approximate the transient crater volume (based on [1,3]) was used to differentiate between the final or full crater volume, the excavated crater, and spallation effects that dominate experimental cratering in solid rocks. This method shows that the unproportional increase in cratering efficiencies is largely due to an increase in spallation, while the transient craters behave according to scaling laws. Strength scaling laws were then used to determine the reduction of dynamic spall strength in large-scale experiments with 12 mm projectiles, and show a decrease by a factor of 1.8-3.6.

The decrease in spall strength is very likely related to a combination of strain rate reduction, prolongation of the pressure pulse and the Weibull effect. These three effects constrain how microflaws coalesce into large fractures and which pressures are necessary for fracture formation. The interrelation of these effects is complex. The lack of increase in cratering efficiency for the transient craters suggests that at high strain rates closer to the point of impact the Weibull effect is subdued, as is discussed in recent studies by [4,5].

Further variations in spallation volumes are observed between different target materials. Under the same impact conditions, quartzite and wet sandstone targets have more spall than dry sandstone targets. The decrease in spall is assumed to be controlled by increased porosity.

These results stress the complexities of rock failure under dynamic conditions. A more detailed understanding dynamic material behavior is therefore vital when addressing small-scale planetary cratering problems in scaling and numerical modeling.

References: [1] Kenkmann T. et al. 2011. *M&PS* 46:890–902. [2] Poelchau M. H. et al. 2013 *M&PS* 48:8-22. [3] Dufresne et al. 2013 *M&PS* 48:50-70. [4] Kimberley J. et al. 2013 *Acta Materialia* 61:3509-3521. [5] Mastilovic S. 2013 *Continuum Mechanics and Thermodynamics* 25:489-501.