EXPERIMENTAL CRATERING IN QUARTZITE, TUFF AND SANDSTONE: FINAL AND TRANSIENT CRATER VOLUMES. M. H. Poelchau[1], T. Kenkmann[1], T. Hoerth[2], A. Deutsch[3], K. Thoma[2], F. Schäfer[2]. [1]Institut für Geo- und Umweltnaturwissenschaften, Universität Freiburg, D79104 Freiburg, Germany, [2]Fraunhofer Ernst-Mach-Institut (EMI), Freiburg, [3]Institut f. Planetologie, WWU Münster, (michael.poelchau@geologie.uni-freiburg.de).

Introduction: The MEMIN research unit is investigating the role of sedimentary target materials on the cratering process. Following experimental campaigns that focused on dry and water-saturated sandstone targets [1,2] we have expanded the range of target materials to quartzite and tuff.

Cratering Experiments: Seven impact experiments were performed at the two-stage light-gas gun facilities of the Ernst-Mach Institute [3] on quartzite and tuff targets. Spherical D290-1 steel projectiles with diameters of 2.5 and 12 mm were accelerated to ~5 km/s. Targets were 20 cm edge length cubes and 80x80x50 cm blocks.

Quartzite and tuff as target materials were chosen to cover a wider range of porosities in comparison to the previously used sandstone (23% porosity). The quartzite has <1% porosity; its uniaxial compressive strength (UCS) is 292 MPa. The tuff has 40% porosity and a UCS of 23.1 MPa.

Results: Crater volumes in dry tuff, quartzite and dry sandstone targets are all similar for the same impact conditions, despite the large range of target strengths. While both the target's strength and porosity are parameters that can reduce crater size, these two parameters are usually inversely correlated for geological materials. Saturating pore space with water leads to an increase in crater volume in both tuff and sandstone by reducing the dampening effects of porosity on the shock wave, while keeping the target's UCS constant.

Strength Scaling: As both porosity and strength are important factors for crater size, π-group scaling can be used to factor out the effects of target strength. Experiments in low-strength sandstone and tuff targets with higher porosities have much lower cratering efficiencies than expected for (non-porous) π_3 values of the quartzites (π_3 factors in target strength, density, and impact velocity). Increasing pore-space saturation effectively reduces porosity effects on crater volume and cratering efficiency, and these values lie closer to the non-porous quartzite trend.

Transient Craters: Due to the interaction of the shock wave with free surfaces of the target, large pieces of spalled material are ejected. This alters the crater morphology and increases crater volume. To discern spall effects from the excavation process and to determine the volume of the transient crater, parabola are fitted to the scanned crater profiles following a method described in [2,4].

Transient crater volumes are only ~15-50% of the volumes of the "final" craters. On average, quartzites have smaller transient craters (13-26%) than sandstones (21-50%) or tuffs (27-33%), relative to final crater volumes. Somewhat surprisingly, transient crater volumes are also smaller in large-scale experiments performed at the EMI's "XL" light gas gun [3]. E.g., sandstones impacted by 10-12 mm projectiles have transient craters with 31±7% of the final crater volume, while sandstones impacted with 2.5 mm projectiles have 47±2%. These values imply that spallation is increased in quartzites and in large-scale experiments.

There are several possible explanations for the observed spall behavior. The increase in spallation in quartzites may be related to higher crack propagation speeds than in sandstone [5], or to the correlation between spall thickness and the target's tensile strength, which are proposed to be directly proportional [6].

The increase in spallation in large-scale experiments may be correlated to projectile size. Larger projectiles generate a longer pressure pulse upon impact. These longer pressure pulses increase the number of tensile fractures formed and also reduce the pressure threshold at which tensile fractures form [7,8]. On the other hand, the target block geometry (cubes vs. flatter cuboids) may influence how the shock wave is reflected from the back of the target, potentially causing a second wave of spallation.

Outlook: Constraining target effects on cratering and differentiating between excavation and spall processes help to produce detailed data sets that serve to validate numerical models [9]. In turn, these models help to understand planetary scale cratering processes.

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