CATCHING AS MUCH INFORMATION AS POSSIBLE – AN EFFICIENT AND EASY-TO-BUILD EJECTA CATCHER FOR HIGH-VELOCITY IMPACT EXPERIMENTS F. Reiser[1], A. Dufresne[1], M. H. Poelchau[1], A. Deutsch[2], T. Kenkmann[1] and the MEMIN Team. [1]Institut für Geowissenschaften – Geologie, Universität Freiburg, Germany; [2]Institut für Planetologie, Universität Münster, (fiona.reiser@geologie.uni-freiburg.de)

Introduction: MEMIN (Multidisciplinary Experimental and Modeling Impact Research Network) is focused on the formation of experimental impact craters into geological materials. Next to high speed video documentation and ultra-sound sensoring, the development and application of ejecta collection devices plays an important role during the experiments [1]. Ejecta recovery of high-velocity impact experiments on rock targets is essential to enable an effective acquisition of a rich database for analyses of the respective ejecta processes. Different approaches of custom ejecta catcher design have been published for different experimental set-ups, e.g. [2,3]. A very effective though expensive capture material used for sampling of cometary dust particles is aerogel [4]. Here, we present a new custom design with easily available material, using phenolic foam and Vaseline, which proved to be adequate for capturing ejecta in high-velocity impact experiments with a two-stage light gas gun [5].

Catcher design and construction: The intention in the experimental series is the capture of all types and sizes of ejecta enabling high spatial resolution and minimal secondary mechanical breakage through ejecta impact and extraction. To achieve this specific objective, Vaseline and phenolic foam were chosen as appropriate materials and assembled using a modular system. Vaseline is degassed in a vacuum oven at melting temperature (10-15 mbar, 90° C) for six hours, then evenly poured onto Plexiglas tiles, cooled and hardened in air before the tiles were mechanically fixed to one half of a metal carrier plate (Fig. 1). Phenolic foam blocks were used to cover the other half of the carrier plate. Vaseline can be easily dissolved in heated (90°C) petroleum ether, enabling complete ejecta particle extraction, whereas particles in the phenolic foam have to be extracted manually.

Experimental setup: Ejecta catchers were placed inside the target chambers vis-à-vis to the rock target surfaces, with a distance of approximately 50 to 53 cm in the case of the XLLGG ("extra large" light gas gun) experiments (see Table in [1]). In the discussed experiments, referred to here as D3, D4 and D5, 1 cm spheres of Campo del Cielo meteorite served as projectiles and were accelerated to 4.5, 3.5 and 2.5 km/s in a target chamber evacuated to 300 mbar. 50 cm Seeberger sandstone cubes from layer SB3 were used as targets, marked with rings of paint augmented with specific trace element ratios on the center of the target surface for reconstruction of excavation and ejection paths. For details on the setup and excavation process see [1] and [6].

Results: The ejecta imprint on both catcher materials shows distinct differences: The Vaseline catcher displays small ejecta craters that contain the captured material. Crater sizes correlate with impact energy. Ejecta hitting the foam catcher produced penetration holes whose depth correlate with the impact energy. In both catchment systems a concentric zoning and a concentration of material in a radial alignment outwards from the catcher center (Fig. 1) was observed. In the case of D3, the concentric zones consist of a ca. 5 cm wide faint outer ring of very fine high-velocity ejecta material (zone 3 in Fig. 1), which corresponds to an ejection angle of ~55° to 50° (in relation to the target surface). An intermediate area (zone 2) contains a mixture of large spall fragments and finer high- to medium-velocity ejecta, corresponding to an ejection angle of 67° to 55°. The inner ring (zone 1) holds the largest fraction of total material captured. It extends from the center to an ejection angle of ~ 67° and shows locally melted Vaseline and scorch marks in the phenolic foam. The initial pilot study at the XLLGG with 1cm steel spheres at 5.3 km/s [5,7] showed that experiments involving Seeberger sandstone (layer SB5) with ~40% water saturation produced very sharp ejecta imprints on a fiberboard catcher plate suggesting a significant influence of pore water on ejecta behavior.

Grain size distribution: Ejecta mass calculations are obtained through the target density and determination of the crater volume by 3D scanning [8]. Together with collected ejecta output from the catcher and target chamber this gives reasonable information on the total ejecta mass and grain size distribution and serves as a reference for numerical modeling. Grain size distribution of the XLLGG experiments on dry sandstone indicate a comminution behavior dominated by the initial target grain size (70-100 µm) which shows no variation for different impact velocities and energies. The fine fractions (<125 µm) determined by laser diffraction, show significant comminution for the XLLGG experiments on dry sandstone whereas for SLGG ("space" light gas gun) experiments (A3, A5) comminution was less effective (Fig. 2). However, grain-size results for SLGG experiments A3 and A5 are preliminary and will be evaluated in more detail.

Information contained in Vaseline catcher: Image processing of Vaseline tiles enables statistical space-resolved analyses of distribution, characteristic diameters and shapes of ejecta craters. These analyses reveal an outer ring of small circular (less than 2 mm diameter) high-velocity ejecta craters in zone 3 and larger, irregularly shaped craters from spall fragments, occasionally mixed with high-velocity circular ones towards the center. Vaseline tiles used in the XLLGG experiments clearly display an inversion of the paint ring sequence applied onto the target surface, showing that material from the crater center has been preferentially ejected towards the outer high-velocity ejecta zone (zone 3) on the catcher and vice versa.

Information contained in phenolic foam catcher: In the XLLGG experiments (D3, D4, D5), foam block thicknesses of 3.5 cm were used, which turned out to be insufficient for high-velocity ejecta grains, whereas 7.5 cm thick blocks intended for a second campaign are expected to be sufficiently thick. Phenolic foam easily allows for analysis of ejecta particle penetration paths which can be statistically evaluated for penetration depths and vectors by 2D-sections (Fig. 3) or through micro CT scanning. In combination with ejecta grain sizes and phenolic foam material parameters, this method can provide estimates on ejecta grain velocities and ejecta energy. Impacts of ejecta grains into phenolic foam as well as into the Vaseline catcher system are predominantly "soft"; most grains are therefore suitable for further microanalysis.

Discussion and Outlook: Our custom ejecta catcher design successfully acquired data on several ejection processes, which currently are still being evaluated. Further work will focus on statistical analysis of ejecta craters and penetration paths in Vaseline and phenolic foam as well as on ejecta grain microanalysis. Preliminary microanalysis of the D3 XLLGG impact experiment revealed abundant fragmented quartz grains, heavily kinked micas and vesicular foam textures of quartz-projectile-mica melt aggregates, the latter predominantly inside the central catcher zone (zone 1). The outer high-velocity ejecta ring (zone 3) displays fragmented quartz grains with marginal melt films. For the D3 XLLGG experiment, PDF structures in quartz have been found associated to partially molten ejecta fragments from zone 1 [9], indicating that highly shocked and subsequently heated target material is concentrated in this catcher zone.

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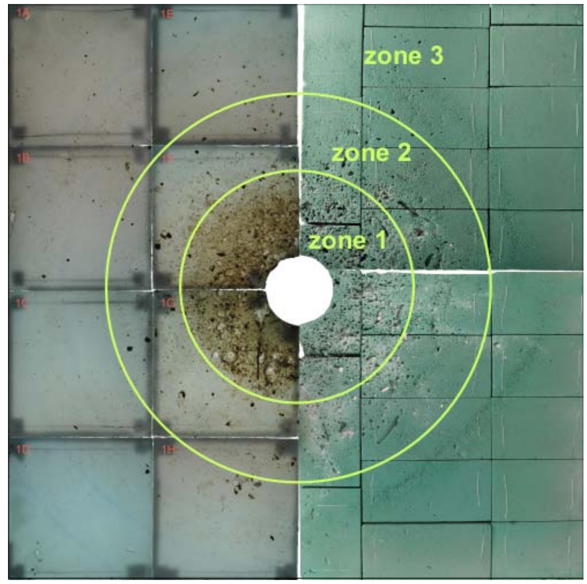

Fig. 1.: Ejecta catcher after D3 impact. Left: Vaseline tiles. Right: phenolic foam. Catcher size is 104x104 cm. For explanation see text.

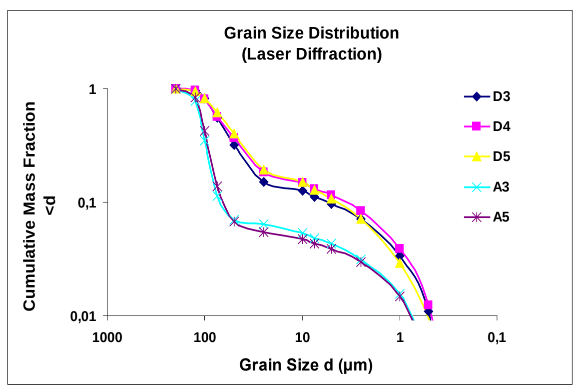

Fig. 2: Grain-size distributions of ejecta <125 µm for impact ejecta from XLLGG experiments compared to SLGG impact experiments on dry Seeberger sandstone (SB3). For explanation see text.

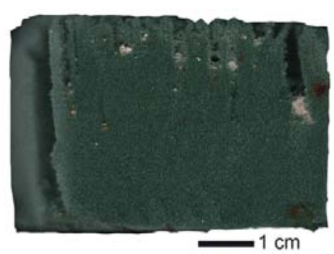

Fig. 3: Penetration paths in 2D phenolic foam section from D3 ejecta catcher.