INSTRUMENTATION OF IMPACT EXPERIMENTS USING LITHIFIED ROCKS

M. H. Poelchau[1], T. Hoerth[2], A. Ueno[3], M. Ebert[3], F. Schäfer[2], A. Deutsch[4], I. Domke[4], D. Moser[5], T. Kenkmann[1]. [1]Institut für Geowissenschaften, Universität Freiburg, D-79104 Freiburg, Germany. E-mail: michael.poelchau@geologie.uni-freiburg.de. [2]Fraunhofer Ernst-Mach-Institut, Freiburg. [3]Museum für Naturkunde, Berlin, [4]Institut für Planetologie, Universität Münster, [5]Centrum für Baustoffe und Materialprüfung, TU München.

Introduction: We report on a recent set of impact cratering experiments on sandstone that have been performed at the two-stage acceleration facility of the Ernst-Mach-Institut in Freiburg, Germany. These experiments were carried out (i) to test different catchment assemblies to collect fragments in a defined manner, (ii) to calibrate different high speed framing cameras, (iii) and to employ ultrasound sensor systems to record pressure waves in the target during and after the experiment.

Experimental setup: In the campaign, 2.5 mm diameter projectiles weighing 67 mg and made of the alloyed heat treatable steel D290-1 were accelerated to ~5 kms^{-1}. Pressure in the target chamber was 100 mbar. Each projectile impacted vertically onto the flat surface of a sandstone cube of 20 cm edge length. We used a fine-grained variety of the porous “Seeberger Sandstein” [1]. The cubes were equipped with two sets of multichannel ultrasound sensors for three-dimensional in-situ measurement of the passage of the shock wave through the target and real-time dynamic fracture growth. The impact and ejecta processes were monitored with two high speed cameras at 10^5 fps and $5*10^5$ fps.

The ejecta was captured with specific catchers positioned parallel to the target surface at ~25 cm distance. Different materials were tested for their capability to capture the very fine-grained high-speed ejecta: They included foam rubber, gelatin, viscous silicone, Vaseline and a phenolic foam (used for flower arrangement). The best capture results were achieved with Vaseline and phenolic foam.

Preliminary results: The high speed videos show the development of an initial ejecta cone with high-speed ejecta that reflects the excavation process, and in addition, spallation of larger fragments. After roughly 50 µs, atmospheric effects begin to influence the shape and further development of the ejecta cloud. Exterior ring vortex winds appear to pinch off the ejecta cone, while later-stage atmospheric effects appear to force the ejecta into a tube-shaped curtain that expands perpendicularly to the target surface. These effects are also reflected in a qualitative analysis of the ejecta catchers, in which fine particles can be found distributed radially corresponding to ejection angles >40° from the target surface, while the majority of the mass of ejecta is concentrated within a 5 cm radius in the center of the catchers, consisting of fine particles and spall fragments.

Results show that the cratering efficiency π_v is reduced by ~23% when the projectile impacts parallel to target layering (π_v=254) as opposed to perpendicular to target layering (π_v=328), which most likely reflects the reduction of the spallation process. Cratering efficiency is also lower compared to the MEMIN pilot experiment (π_v=419), in which a 10 mm diameter steel sphere weighing 4.1 g struck dry Seeberger sandstone at 5.3 kms^{-1} [1].

Acknowledgments: The MEMIN research unit FOR 887 is funded by the German Research Foundation DFG.

References: [1] Kenkmann et al. 2010, Proc. 11th Hypervelocity Impact Symposium No.97, in press.