MAPPING OF MICROSTRUCTURAL DEFORMATION IN EXPERIMENTAL IMPACT CRATERS FORMED IN SANDSTONE

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Introduction: As part of the MEMIN project experimental hypervelocity impacts into porous sandstone were conducted at the Ernst-Mach-Institut (EMI), Germany [1]. In combination with real-time investigations of the ejection process and ultrasound signals, spatially resolved impact damaging of the target was systematically investigated with a scanning electron microscope (SEM). As first result four distinct subsurface zones can be discriminated by their deformation mechanisms.

Methods: A 2.5 mm sphere of high alloyed steel impacted into a 20 cm sandstone cube with a velocity of 4.8 km/s. Acceleration was achieved by a two stage light gas gun (Space Gun, EMI)[2,3]. The sandstone has a porosity of ca. 22% and a quartz content of 94 wt%. The sub-rounded quartz grains are cemented by quartz and clay mineral coatings. For investigations the impacted block was bisected parallel to the impact direction and thin sections were prepared directly underneath the crater floor. For a detailed mapping ca. 300 SEM photomicrographs (160x, BSE) were merged to a high resolution image of the crater subsurface.

Results: The formed crater has a diameter of 5.76 cm and a depth of 1.1 cm. Deformation gradually decreases with increasing distance from the crater floor. The outermost zone (>3.6 projectile diameters ($\varnothing_p$) from the impact center) of apparent deformation is dominated by concussion fractures which are well known from natural impacts [4]. These intragranular fractures occur on grain-grain contacts and have a preferred radial orientation. Macroscopic radial fractures as described for cratering in basalt [5] were not detected. The second zone of deformation (2.9-3.6 $\varnothing_p$ from the impact center) is characterized by localized compactional shear bands in which grain comminution along with shearing and compaction occurs. This zone has a hemispherical appearance beneath the crater floor with a thickness of ca. 2.2 mm. In the third zone (1.7-2.9 $\varnothing_p$ from the impact center) the compaction and grain crushing is pervasive. Pore space is completely crushed and filled with small quartz fragments and clay mineral aggregations. This zone has a maximum thickness of 3.1 mm. The innermost zone (1.4-1.7 $\varnothing_p$ from the impact center) of deformation in contact to the crater floor has a maximum thickness of 0.9 mm. In addition to the deformation described for zone three, tensional fractures occur sub-parallel to the crater floor. These fractures are up to 1.2 mm long and formed new pore space in the compacted host rock. Macroscopic spall fractures are traceable laterally at distances >5 $\varnothing_p$ from the impact center

Conclusion: The sub-surface deformation in shocked porous sandstone can be differentiated into four different zones by the occurrence of different deformation types. A more detailed analysis of deformational modes is planned to give further insights into deformation mechanisms in porous targets during shock loading.

References: [1] Kenkmann T. et al.. 2011. *MAPS* in press. [2] Schäfer F. et al. 2006. *ESA SP-612*. [3] Poelchau M. H. 2011. Abstract #1824. 42th Lunar & Planetary Science Conference. [4] Kieffer S. W. 1971. *J. Geophys. Res*., 76, 5449-5473. [5]°Polanskey C. A. and Ahrens T. J. 1990. *Icarus, 87, 140-155*