FORMATION OF SHATTER CONES IN THE MEMIN IMPACT EXPERIMENTS.

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Introduction: Shatter cones are an important diagnostic feature for the discovery and validation of impact structures. They are easily identifiable in the field and the only macroscopic feature considered as evidence for shock metamorphism. However, their occurrence is heterogeneous throughout the crater record and the precise mechanism of shatter cone formation is still enigmatic. Most authors align the formation of shatter cones with the passage of the shock front or the release from shock loading as it interacts with a heterogeneity [1-3]. However, none of the existing models provide a satisfying concept that explains all relevant aspects of shatter cones, namely, their (i) conical to hyperbolic shape, (ii) the presence of diverging striations and grooves, and (iii) their hierarchical bifurcation that leads to the horsetailing effect.

In our study we are attempting to constrain the physical boundary conditions necessary for the formation of shatter cones. So far we recovered several fragments from the MEMIN cratering experiments, displaying slightly curved and conical to hyperboloid fracture surfaces marked by fine striations.

Methods: The cratering experiments have been carried out with two-stage light gas guns at the Ernst-Mach Institute in Freiburg. We used 20 to 80 cm sized target cubes of sandstone, quartzite, limestone and tuff which were impacted perpendicular to the target surface at high velocities by aluminum, steel and Campo del Cielo projectiles with a diameter of 2.5 to 12 mm under dry and wet conditions [4].

By hand picking and soft stimulated fracturing of the crater's subsurface we thoroughly examined the ejecta and the crater itself. A detailed 3D model and a morphometric analysis of each specimen found was carried out with a Bruker AXS Contour GT-K0 white light interferometer (WLI).

Results: The millimeter to half centimeter sized shatter cone fragments were found in experiments with maximum Hugoniot pressures of 46 to 86 GPa. The target cubes of sandstone, quartzite and limestone were impacted with velocities from 4.6 to 7.8 km/s. Most of the recovered shatter cones were found within the ejecta. SEM analysis of these fragments showed vesicular melt films alternating with smooth polished surfaces [5]. The 3D scans with µm-accuracy display morphologies coherent with shatter cones of various terrestrial impact craters.

Discussion: We are currently try to constrain the shock pressure interval, the plastic strain, and the shock duration the fragments have experienced. We hypothesize the vesicular melt films predominantly form at strain releasing steps and suggest that shatter cones are probably mixed mode fractures. The thorough description of the shatter cone geometry will offer critical tests for the debated shatter cone formation models.

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