RECUNSTRUCTION OF THE MORASKO METEORITE IMPACT: FROM ATMOSPHERIC ENTRY TO INDIVIDUAL CRATER FORMATION – INSIGHT FROM NUMERICAL MODELING

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Introduction: Impact events producing crater strewn fields happen within a time interval of ~500 years [1] and pose a natural hazard to modern civilization. A quantitative analysis of the consequences of such events is important for hazard assessment and mitigation plans. Terrestrial strewn fields represent a natural laboratory for such studies. The Morasko strewn field is located near Poznan, Poland. It comprises 7 well-preserved craters with diameters from 20 to 90 meters. In addition, numerous meteorites have been recovered in the area. Their distribution and composition suggest an iron projectile with the trajectory from NE to SW [2].

Here we present modeling results of the atmospheric break-up of the meteoroid, the distribution of fragments and the formation of individual craters on the ground during the Morasko event. Our goal is to reconstruct the most probable impact scenario, physical processes during the crater formation, and their environmental effects.

Methods: An impact scenario for strewn field formation can be subdivided into two separate stages (1) the passage of the projectile through the atmosphere; (2) the formation of craters on the ground. First, using the atmospheric entry model (described below) we explore the possible parameters space searching for the pre-atmospheric mass, velocity and trajectory angle, which can result in the observed number and size distribution of craters. Using the pi-scaling method [3], we estimate the size of transient craters resulting from the impact of projectiles with masses and velocities defined by the atmospheric disruption model. In order to gain further insights of the crater formation process we also simulated the formation of individual craters with multi-rheology, multi-material hydrocode iSALE2D [4-5].

Atmospheric entry model: We integrated numerically standard equations describing ablation and deceleration of impacting bodies in the atmosphere [6]. When dynamic loading exceeds meteoroid internal strength, we use the modified "Pancake approximation" [6] to simulate the motion of the deformed meteoroid. Using Monte Carlo methods and standard cumulative size-frequency distribution, we assign mass, position and velocity to each big fragment that move independently to the ground. Fragments with sufficient mass and velocity may be subjected to another fragmentation cycle.

Scaling of impact crater size: We carried out a series of numerical experiments varying the impactor size with the multi-rheology, multi-material hydrocode iSALE2D. We assumed target properties (strength and porosity) that are realistic for the given target situation at Morasko. Based on these models we determined scaling-parameters adjusted to the target properties at Morsako that slightly deviate from those determined in laboratory experiments with dry sand targets [5].

Modeling the impact process: In addition we simulated the crater formation process in order to gain further insights of the shock wave propagation, the crater excavation and distribution of ejecta. We used the mass and vertical velocity defined by the atmospheric entry model as initial projectile properties. To study ejection process we used tracer particles located initially in the center of each cell of our computational target.

Results: We present possible scenarios of the Morasko strewn field formation, including: pre-entry parameters of the Morasko meteoroid, mass and velocity distributions of crater-forming fragments, the reconstruction of individual craters, and the detailed description of ejecta. We provide the range of energies involved at each stage of the Morasko impact event. We also discuss environmental consequences of similar events in the future.

Acknowledgement: The work was supported by National Science Center (Poland), grant no. 2013/09/B/ST10/01666

References: [1] Artemieva N. and Shuvalov V. (2011) JGR, 106, 3297. [2] Stankowski W. (2013), PWN. [3] Holsapple and Housen (2007), Icarus 187, 345. [4] Amsden A. A. et al. (1980) Los Almos National Laboratory Report LA-8095. [5] Wünnemann K. et al. (2006) Icarus 180, 514. [6] Chyba C. F. et al. (1993) Nature, 361, 40.