# CAMPO DEL CIELO STREWN FIELD: MODELLING THE FORMATION OF IMPACT FUNNELS.

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**Introduction:** The Campo del Cielo strewn field, located in the south of the Chaco province, Argentina, formed about 4000 a ago due to the impact of an octahedrite iron asteroid [1,2,3]. It extends about 14 km and ~3.5 km in impact and lateral direction, respectively. Recent numerical reconstructions of the strewn field yielded impactor parameters of min. 7500 – 8500 tons, 14.5-18.4 km/s entry velocity, and max. 16.5° entry angle [4]. Beside four elliptical impact craters with diameters of 70  - 115 m, penetration funnels with intact meteorites up to 30 tons in weight have been formed during the event [1,2]. In this study, we analyse possible conditions of funnel formation, which may help to constrain the impactor parameters [4].

**Methods:** The funnel formation is simulated using the iSALE-2D shock physics code [5], which has been applied to similar problems, previously [6]. Here, we explore the influence of impact velocity and target porosity on the funnel formation processes. Initial conditions are consistent with the atmospheric entry model, i.e. we model a 30 tons fragment at impact velocities between 600 m/s – 1600 m/s. The target is set up with a porosity of 40% to represent the local loess unit at the side of impact. Further, the porosity is varied between 30-50% at a constant impact velocity of 800 m/s. To test the effect of impact angle on the funnel formation process, we used the 3D version of iSALE to simulate impacts at 600 m/s at varying angles from 15° to 90°.

**Results:** Preliminary analysis of impact experiments [7] have shown that in the CdC case (iron projectile and loess as a target) funnel formation and projectile survivability is possible at impact velocities below 1 km/s. Even though the iSALE models confirm this estimate, the 1 km/s is probably the upper limit of impact velocity allowing survivability of high strength iron meteoroids impacting into loess. At this velocity, the fragment is already deformed to a significant extent. A further increase of impact velocity leads to an increase in projectile deformation (pancaking) up to the projectile breakup. At velocities above 1 km/s, funnels are gradually transformed into impact craters due to their increase in diameter. At 1.6 km/s, the cavity widens about 5 times the projectile size and the depth/diameter ratio approaches 1. .

3D models reveal an interesting effect: at shallow angles even a low-velocity projectile is reflected from the surface and an elliptical crater, not a funnel, is formed. An impact angle should be at least 25° to avoid the reflection.

**Conclusions and Discussion**: Our findings suggest that the funnels of the Campo del Cielo strewn field are in line with results from recent atmospheric entry simulations [4]. Even though the predicted entry angle of 16.5° is below the threshold for funnel formation (25°), atmospheric deceleration of fragments from cosmic velocities down to 0.6 – 1 km/s steepens their trajectories. Our findings also contradict field estimates of the CdC impact scenarios in which impact velocities are in the range of 3-5 km/s at an angle of 9-10° to horizon [1]. We discuss possible ways to reconcile our models with observations at the meeting.

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