THE STEINHEIM IMPACT CRATER (GERMANY) – WHERE IS THE EJECTA BLANKET?

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Introduction: The exceptionally well-preserved ~24 km Nördlinger Ries and the ~3.8 km Steinheim Basin impact craters (e.g., [1]) are situated on the limestone plateau of the Swabian-Franconian Alb. Both impact craters are thought to have formed simultaneously in the Middle Miocene by the impact of a binary asteroid (e.g., [2]). The Nördlinger Ries crater is unique in terms of the state of preservation of the impact crater morphology and its impact ejecta blanket. The Steinheim Basin exhibits a distinct morphological depression that is filled by a lithic impact breccia preserved in its original thickness and position. However, no impact ejecta are known further outside the Steinheim crater.

Description of the Problem: The transfer of up to 2 crater radii for a continuous ejecta blanket and of 2 to 3 crater diameters for distal ejecta (e.g., [3]) would be typical for terrestrial impact structures. Proximal and medial Steinheim ejecta could be expected within a distance of up to 4 km, distal ejecta within a distance of up to 12 km from the crater rim. However, an intense search for proximal or distal Steinheim ejecta outside the actual impact crater was not successful. In the light of the very similar sedimentary target setting and erosional history in the Ries-Steinheim area, the contradiction of a widely preserved Ries ejecta blanket versus the apparent lack of any remnants of Steinheim ejecta that travelled beyond the crater rim remains puzzling.

Discussion and Results: Is the apparent lack of impact ejecta outside the Steinheim crater a primary effect or the result of erosion? Paleogene (pre-Ries), Middle Miocene (± time of impact) and Middle to Late Miocene (post-impact) sediments occur in the surroundings of the Steinheim Basin within a distance of a few kilometers. These relics of a once more extensive sedimentary Alb cover suggest that Steinheim ejecta would have probably survived if originally deposited in considerable amounts. Target porosity has a significant influence on cratering efficiency, as well as on the volume and distribution of excavated ballistic impact ejecta (e.g., [4]). The calculated volume of ejecta with high velocities drastically drops with an increase in target rock porosity. Partial (or total) suppression of ballistic ejecta deposition outside the impact structure occurs when the source craters are formed mostly by bedrock compaction, which requires target rock porosities greater than about 30–40% [4]. The average porosity of the Steinheim target rocks ranges between ~21% and ~44%; due to intense karstification of the Upper Jurassic carbonates that represent the main portion of the Steinheim target rocks, the total target rock porosity probably tends towards the higher value, potentially sufficient to reduce the produced amount of impact ejecta deposited outside the impact structure. We thus interpret the apparent absence of ejecta in the surroundings of the Steinheim crater as a likely primary effect related to the compression of the porous target rock and a resulting suppression of impact ejecta outside the crater.

References: [1] Buchner, E. and Schmieder, M. 2010. *Meteoritics Planet. Sci.* 45:1093-1107. [2] Stöffler, D. et al. 2002. *Meteoritics Planet. Sci.* 37:1893-1907. [3] Melosh, J. 1989. Impact Cratering: A Geologic Process. 245p. [4] Housen, K.R. and Holsapple, K.A. 2012. *Icarus* 219:297-306.