REMOTE SENSING ANALYSIS AND LANDSCAPE EVOLUTION MODELING OF THE BOSUMTWI IMPACT STRUCTURE, GHANA: INDICATIONS FOR EJECTA RAMPARTS. G. Wulf[1] , S. Hergarten[1], T. Kenkmann[1], [1]Institute of Earth and Environmental Sciences -Geology-, Albert-Ludwigs-University Freiburg, Germany, gerwin.wulf@geologie.uni-freiburg.de.

Abstract: Based upon the terrestrial Bosumtwi crater, we get new insights into the impact crater formation process by combining remote sensing and geomorphological analyses with landscape evolution models. We prove whether the current morphology of Bosumtwi crater can be the result of erosion of a typical martian-type or lunar-type impact crater. We suggest that a fluidized ejecta blanket with circumferential rampart lobes surrounded the pristine Bosumtwi crater and that the current morphology is the result of weakly eroded ejecta ramparts.

Introduction: The Bosumtwi impact crater in Ghana (06°30`N, 01°25`W) is one of the youngest and best preserved terrestrial impact craters [1]. The 1.07 Ma old impact structure has a pronounced crater rim with a diameter of 10.5 km [2]. A striking feature of the Bosumtwi impact structure is a shallow, annular moat at 7-8.5 km from the crater center directly beyond the crater rim, surrounded by a concentric topographic high at 18-20 km radial distance from the impact center [3, 4, 5]. It was suggested that preferential removal of impact ejecta could be the reason for this shallow annular depression [5]. Other explanations included an original depositional pattern as well as impact-induced concentric fracturing as causes for this annular moat [3]. Here we present results of remote sensing analyses and landscape evolution modeling and hypothesize that the peripheral morphology of Bosumtwi crater results from a fluidized ejecta blanket with rampart structure similar to martian DLE craters.

Methods: We used digital elevation data from the TanDEM-X mission (TerraSAR-X add-on for Digital Elevation Measurements) with a mesh width of 0.4 arcsecond (~12 m at the equator) as base data to create a DEM mosaic of the Bosumtwi crater and the surrounding area. A stream network was delineated and watersheds and catchment areas were determined by combining the derived flow directions with defined outlet points of the watersheds. We compared the results of Bosumtwi crater with a martian rampart crater of similar size. The martian crater Steinheim (190.65°E 54.57°N), a well-preserved and young 11.2 km diameter double-layered ejecta (DLE) [6], was selected. We used the Ames Stereo Pipeline to build a high-resolution digital elevation model on the base of CTX data [7]. A hypothetical drainage network and catchment areas were derived using the same approach as for Bosumtwi crater. In order to test the hypothesis whether the current morphology of Bosumtwi crater can be the result of erosion of a martian-type or lunar-type impact crater we used landscape evolution modeling on the basis of DEMs (CTX DEMs for Mars and TC DEMs from the Selene mission for Moon). The main approach hereby is to use the current morphology of fresh martian and lunar impact craters as starting point for the erosion modeling and simulate their future evolution under the climatic and lithological conditions of the region around the Bosumtwi crater. The model combines the stream power approach for fluvial incision with a linear diffusion equation mimicking hillslope processes. The stream power approach dates back to empirical studies of Hack (1957) and Flint (1974) and is used in all contemporary large-scale models of fluvial erosion. The diffusion equation was introduced in the context of landform evolution by Culling (1960). Both processes can be summarized in a parabolic differential equation, as reviewed by Robl et al. (2017).

Results: The drainage network of Bosumtwi crater forms a circular pattern in the slightly depressed annular zone beyond the crater rim. Consequently, the crater rim and the crest line of the morphological ring are building concentrically oriented watersheds over more than 80% of the impact structure (Fig. 1).

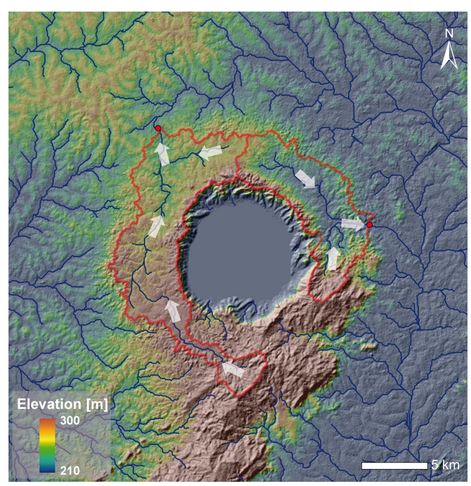

Figure 1: Derived drainage pattern and accordant catchment areas for Bosumtwi crater.

To test the hypothesis that the morphological ring of Bosumtwi crater is the result of partly eroded ejecta deposits, we used landscape evolution modeling on the basis of typical martian (Steinheim) and lunar (Harpalus) impact craters. In the process, we derived surface models after an assumed erosion period of 1 Ma, comparable to the current age of Bosumtwi (1.07 Ma), and 2 Ma. The drainage pattern of Steinheim crater shows a local watershed along the crest line of the rampart and a concentric discharge pattern in the moat area (Figs. 2 a-c) that appear to be relatively stable over time, comparable to Bosumtwi crater (Figs. 2 d,e). The modeling results clearly show that a lunar-like impact crater, represented by Harpalus crater, generates mainly radially oriented drainage networks (Figs. 2 f-h). Neither an annular depression beyond the crater rim nor a concentric morphological ring is recognizable in the initial state as well as the eroded states of the impact crater.

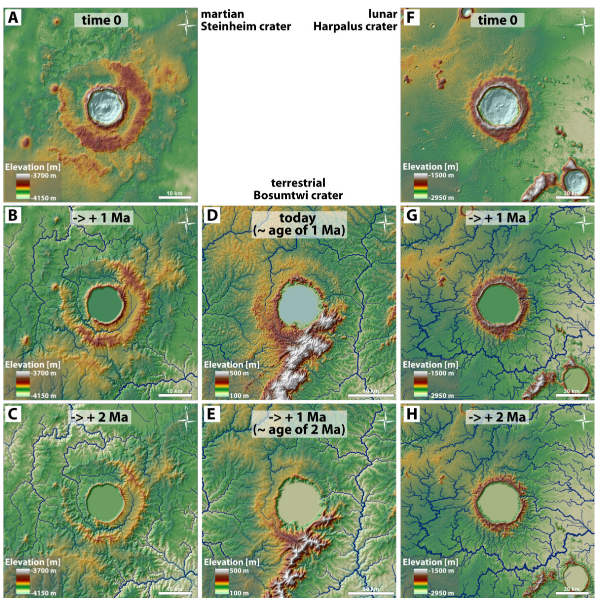

Figure 2: Results of landform evolution modeling and derived drainage networks for a martian-type impact crater (Steinheim crater; A=0 Ma, B=1 Ma, C=2 Ma), a lunar-type impact crater (Harpalus crater; F=0 Ma, G=1 Ma, H=2 Ma) and the terrestrial Bosumtwi crater (D=current state (≙ age of 1.07 Ma), E=1 Ma into the future). The position of the concentric drainage network and drainage divides of Steinheim and Bosumtwi crater remain relatively stable over time.

The morphological ring (rampart) of Bosumtwi crater shows a width of 3.7 km and thus perfectly fits to the range of rampart dimensions of the inner ejecta layer of martian DLE craters [12] (Fig. 3).

Discussion and Conclusions: With the help of landscape evolution modeling it can be demonstrated that the current morphology of the terrestrial Bosumtwi crater cannot be explained by erosional processes of a lunar-like impact crater. Instead, our results show that the morphological characteristics of Bosumtwi crater possess striking similarities to those of martian rampart craters, especially to DLE craters. The rampart dimensions of Bosumtwi crater could represent an inner layer of a DLE crater. We therefore suggest that Bosumtwi crater was originally built as a Mars-like rampart crater and as a consequence that the current morphology is the result of weakly eroded ejecta ramparts.

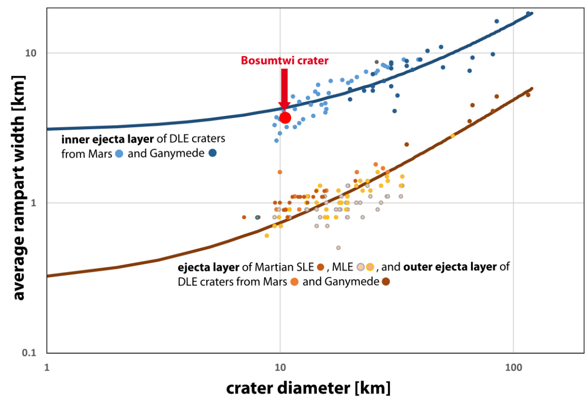

Figure 3: Rampart dimensions of impact craters from Mars and Ganymede (modified from [12]). The rampart width of the terrestrial Bosumtwi crater perfectly fits to the inner ejecta layer of martian DLE craters.

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