RIES CRATER, GERMANY: FURTHER INDICATIONS FOR MARS-LIKE EJECTA MORPHOLOGIES?

G. Wulf[1] and J. Wilk[2], [1]Institute of Earth and Environmental Sciences (Geology), [2]Institute of Earth and Environmental Sciences (Near-Surface Geophysics), Albert-Ludwigs-University Freiburg, Germany (gerwin.wulf@geologie.uni-freiburg.de).

Introduction: The 26 km diameter Ries crater in Germany is a relatively pristine, complex impact crater that was formed during the Miocene (14.34+-0.08 Ma) [1, 2]. The oblique impact [3] occurred in a two-layered target of ~650 m partly water-saturated, subhorizontally layered sediments (limestones, sandstones, shales) underlain by crystalline basement rocks (gneisses, granites, amphibolites) [4], and is characterized by two distinct ejecta lithologies (Bunte breccia and suevite). The continuous ejecta blanket of the Ries crater is built up of a polymict lithic breccia, called Bunte breccia, generally composed of mainly unshocked to weakly shocked sedimentary target clasts, minor amounts of crystalline basement fragments, and reworked surficial sediments [5]. The Bunte breccia is overlain by patches of suevite that are predominantly built up of variously shocked and partly melted crystalline basement material [6, 7] with minor signs of incorporated sediments [8].

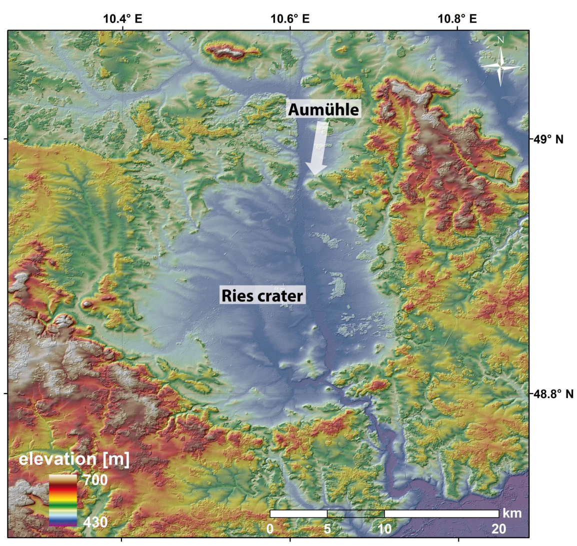

Fig. 1: Overview of the Ries crater and location of Aumühle quarry (TanDEM-X elevation data).

The ejecta distribution of the Bunte breccia deposits of the Ries crater shows striking similarities in shape, dimension and form with Bosumtwi crater in Ghana [9] and martian rampart craters [9-11]. However, the formation of such rampart structures is still controversial and several formation models have been proposed to explain the rampart formation process (see review by [12]). A characteristic feature of a multitude of martian rampart craters are radially oriented grooves and ridges ("striations") that extend nearly over the entire ejecta layer showing many similarities to martian landslides [13-15] (Fig. 2a). Interestingly, the Aumühle quarry near the NE crater rim of the Ries crater where the contact between the continuous ejecta blanket (Bunte breccia) and suevite is exposed shows an extremely undulating and sharp contact with a striations-like appearance that strike radially with respect to the crater center [15] (Fig. 2b).

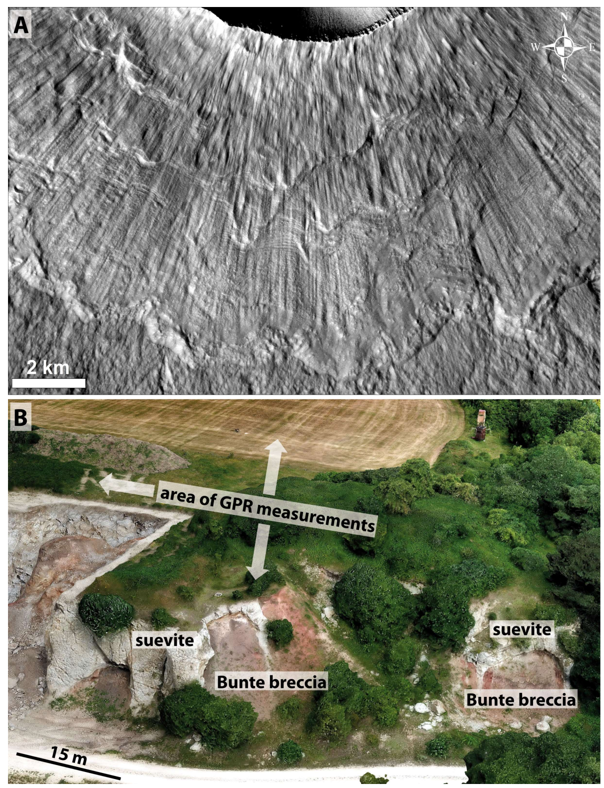

Fig. 2: (A) Striations on the inner ejecta layer of the martian rampart crater Steinheim (CTX imagery). (B) Perspective view of the Aumühle quarry showing an undulating and sharp contact between Bunte breccia and suevite (drone imagery).

If this contact zone shows indeed striations, similar to martian impact craters, further analyses will help to understand not only the formation of striations but also the ejecta emplacement and rampart formation process.

Here we present preliminary results of geophysical and remote sensing analyses to answer the question whether the ejecta blanket of the Ries crater shows surficial striations, similar to martian rampart craters.

Methods: The Aumühle quarry allows a detailed analysis of the contact between the continuous ejecta blanket (Bunte breccia) and suevite. The suevite serves as a sealing feature preserving the original surface morphology of the Bunte breccia. The main goal of this study is to reconstruct the lateral extent of the undulated contact plane between Bunte breccia and suevite by combining photogrammetric and geophysical methods. Aerial images of the entire Aumühle quarry and surrounding areas were taken by a DJI Mavic Pro drone in order to conduct photogrammetric processing and generate digital elevation models (DEMs) and orthoimages using Agisoft PhotoScan software. The derived data allow a detailed mapping of the visible contact zone, more precise a three-dimensional point cloud of the contact zone, and function additionally as reference for the subsequent geophysical analysis. A bi-static pulseEKKO Ground Penetrating Radar (GPR) was used to investigate the subsurface contact between Bunte breccia and suevite with 50 MHz to 200 MHz antennas. In a first step, the capability of the method was validated with regard to the detection of the boundary layer between Bunte breccia and suevite. In further steps, a grid of GPR profiles was taken using the 200 MHz antenna configuration. The spatial arrangement of the grid allows a three-dimensional (x-, y-, z-coordinates) reconstruction of the boundary layer (contact plane).

Results and Discussion: The Aumühle quarry shows an undulating and sharp contact between Bunte breccia and suevite whose relief amplitude is in the order of 5-10 m (Fig. 2b). The striations are a few meters wide and several meters deep. The GPR profiles clearly trace the boundary layer between both units and indicate a continuation of the undulated surface of the Bunte breccia at the subsurface (Fig. 3).

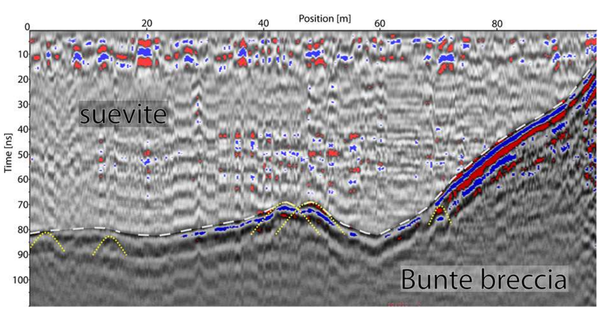

Fig. 3: GPR profile showing the boundary layer between Bunte breccia and suevite. Blue and red contrasts indicate reflection maxima and minima, fitted diffraction hyperbolas presumably from blocks of the Bunte breccia are marked in yellow.

At the current, preliminary state of the analysis, it is not possible to show an area-wide reconstruction of the boundary layer or in other words the original surface of the Bunte breccia over large areas. However, it is planned to merge all contact points of the photogrammetric mapping and all GPR contacts of the boundary layer into one point cloud dataset in order to generate an interpolated surface of the Bunte breccia. The first results look very promising and indicate indeed a lateral continuation of the striations-like ejecta morphology of the Bunte breccia. If this proves to be the case, the results will help to investigate and understand the ejecta emplacement, rampart and striation forming processes, that are of great importance not only for martian impact craters, on the basis of a nearly pristine and easily accessible terrestrial impact crater.

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