IMPACT EJECTA MODELING OF THE BUNTE BRECCIA DEPOSITS OF THE RIES IMPACT CRATER, SOUTHERN GERMANY.

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Introduction: The Ries crater is a relatively pristine, complex impact crater in Germany ~25 km in diameter that was formed during the Miocene (14.34+-0.08 Ma) [1, 2]. The oblique impact [3] occurred in a two-layered target consisting of ~650 m partly water-saturated and subhorizontally layered sediments (limestones, sandstones, shales) of Triassic to Tertiary ages underlain by crystalline basement rocks (mainly gneisses, granites, and amphibolites) [4, 5].

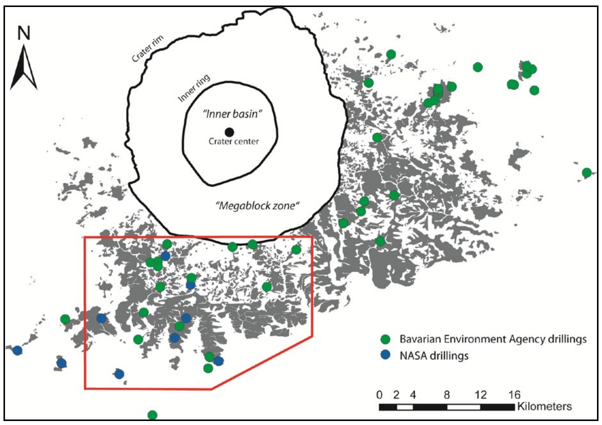

Fig. 1: Distribution of the Bunte breccia deposits (grey) outside the Ries crater with plotted Bavarian Environment Agency (green) and NASA (blue) drilling site locations. The interpolated surface area is shown by the red box.

The rock that builds up the continuous ejecta blanket which occurs up to 45 km distance from the crater center is the Bunte breccia, a polymict lithic breccia. It is generally composed of mainly unshocked to weakly shocked sedimentary target clasts plus a minority of basement clasts and reworked surficial sediments (***Fig. 1***). The ratio of primary crater ejecta to local substrate components decreases with increasing radial range and is thoroughly mixed at all scales [6, 7]. A radial flow of the ejecta is indicated by striations on contact surfaces that are locally deflected by pre-existing paleorelief. The Bunte breccia is interpreted as a “cold”, noncohesive impact formation [6, 7, 8]. Previous interpretations of the Bunte breccia assumed analogies to the Moon: (I) ballistic emplacement, which triggered a ground hugging debris surge [7, 9], or (II) a rolling and gliding surge under high localized confining pressures [10]. Former interpretations did not account for the role of water in the target and in the ejecta blanket. Underground water and the presence of an atmosphere suggest that the Ries it more likely formed analogous to Martian rampart craters [11]. We concern the question if the Ries impact crater is comparable to a double-layered ejecta crater on Mars [12] as two types of ejecta are present in the Ries, namely the Bunte breccias and the Suevite. Furthermore we analyse indications for fluidization and possible rampart formation processes at the Ries crater. Here we present new results of the morphology of the (i) paleo-relief and (ii) the thickness variations of the continuous ejecta blanket with radial range.

Method: By combining digital elevation data and geologic information in ArcGIS (ESRI) and RockWorks14 (RockWare) we will extract the elevation of the lower contact plane (“paleo-surface”) and the contact between the Bunte breccia and the overlain Suevite deposits. The study area is situated south of Ries crater and comprises ~ 400 km^2. The area was chosen because of the highest data density and the widespread occurrence of Bunte breccia as well as Suevite. The dataset is used to constrain the local relief and thickness distribution of the Bunte breccia surface for a comparison to fluidized Martian ejecta blankets. The interpolation between elevation points carried out with the software RockWorks14 led to the reconstruction of the paleo-surface and the Bunte breccia upper contact using the software ArcGIS. The knowledge of the paleo-surface is important when comparing the ejecta blanket with those of Martian craters, because the target relief may notably affect the ejecta flow and may cause possible flow deflections. We used extracted mapping informations of the autochthonous-allochthonous (“Bunte breccia base”) and allochthonous-suevite (“Bunte breccia top”) intersections from the geologic map [13], descriptions of nine NASA drilling sites [7], and included up to 40 drillings carried out by the Bavarian Environment Agency to interpolate the morphology and thickness variation of the ejected Bunte breccia outside the crater (***Fig. 1***). The latter were previously not available for scientific investigations. In addition the recent weathered Bunte breccia morphology was included to obtain mimimum thickness estimations outside the Ries impact crater. In terms of geologic interpretations, the interpolation method “kriging” delivered the best results of the morphology of the paleo-surface and the Bunte breccia top (***Fig. 2***).

Discussion and Results: The southwestern part of the ejecta blanket was promising for this study and delivered a more or less continous morphology and thickness distribution of the Bunte breccia deposits outside the Ries crater. Preliminary interpolation results show that the morphology and thickness of the Bunte breccia varies with increasing distance from the crater center, especially in the southwestern part outside the crater (***Fig. 2, 3***).

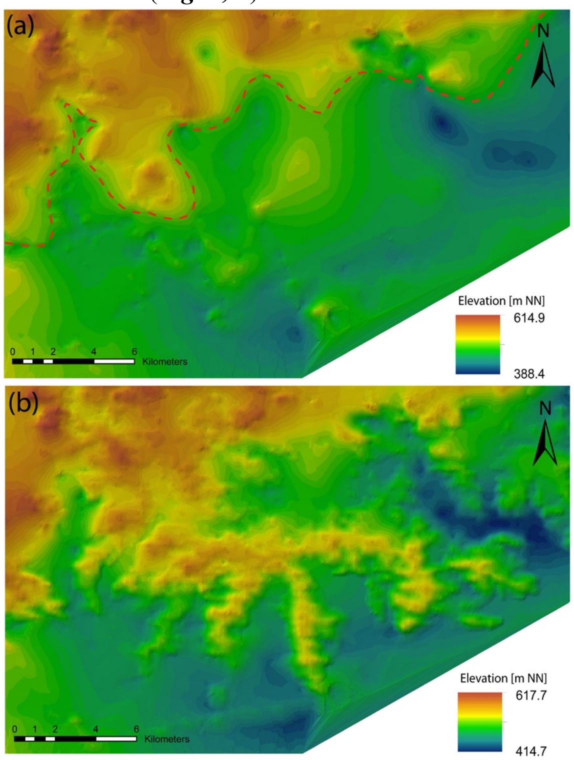

Fig 2. Preliminary results of the interpolated morphology of the (a) paleo-surface and (b) Bunte breccia upper surface. The local relief is controlled by the cliff-line (stippled red line in (a)) that marked the northern shore of the Molasse sea. The study area is shown in Figure 1.

The interpolated paleo-surface reflects the paleo-cliff-line between the autochthonous Malmian limestone in the north and the stratigraphic younger Upper Seawater Molasse sediments in the south (***Fig. 2a***). The interpolated Bunte breccia top shows more or less similar characteristics as the recent morphology of the study area (***Fig. 2b***). The Bunte breccia thickness south of the crater decreases beyond the outer crater rim to a few meter thickness at 15 km distance from the crater center (1.20 crater radii). A steady increase in thickness is then observed in radial range and reaches a point of culmination with up to 99 m thickness at a radial distance of c. 22 km from the crater center (1.76 crater radii) (***Fig. 3***). Beyond this concentrically trending ejecta ridge, the thickness decreases rapidely to less than 40 m. The farthest extent of the southern ejecta blanket is situated at 32 km distance (2.56 crater radii). The erosional relics do not preserve a distal ejecta thickening. The analysis shows that the ejecta thickness distribution clearly deviates from a steady decrease with radial range. Instead a ridge of thick Bunte Breccia could be identified at c. 2 crater radii. This observation of the southwestern part outside the Ries crater is comparable to the morphology charateristics of double-layered ejecta craters on Mars that show elevated rampart features at distances of 2 crater radii from the crater center [12]. However, the white colored area in Figure 3 show a region with missing Bunte breccia bottom datapoints. In the following interpolation steps this problem will be solved by the input of additional allochthonous-autochthonous boundary informations.

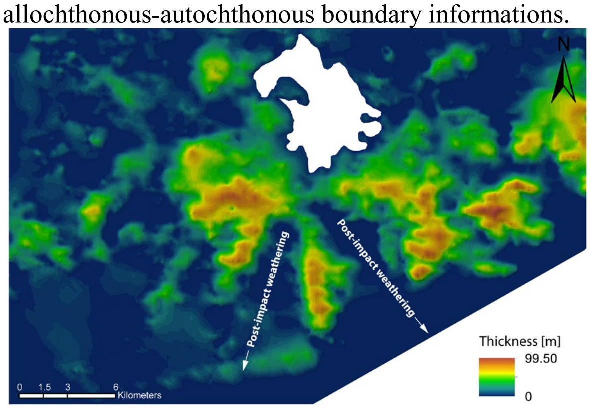

Fig. 3: Preliminary results of the interpolated Bunte breccia thickness. The white area shows a region with missing Bunte breccia bottom datapoints and dark blue areas represent outcroping weathered autochthonous units (e.g., Malmian limestone). The study area is shown in Figure 1.

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