



The Ries impact crater described as an analogue for a Martian double-layered ejecta crater on Earth

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The Ries impact crater (~ 26 km-diameter) is described as a relatively pristine, complex impact crater in southern Germany. The oblique impact occurred during the Miocene (14.9 Ma) and hit into a two-layered target material that consists 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) [1, 2, 3, 4]. The continuous and well-preserved ejecta blanket reaches up to a distance of 45 km from the crater center. It is built up by so called Bunte Breccia material that is described as a polymict lithic breccia. Bunte Breccia mainly consists of unshocked to weakly shocked sedimentary target clasts including a minority of crystalline basement clasts and reworked surficial sediments (e.g., Upper Freshwater Molasses or Upper Seawater Molasses) [5, 6]. Here we present our final interpolation results of the morphology of the paleo-surface and the thickness variations of the continuous ejecta blanket (Bunte Breccia) with radial range outside of the Ries impact crater. Our results were then compared with ejecta distribution characteristics of Martian complex double-layered ejecta craters (DLE) [7].

We combined digital elevation data (ASTER DEM) and geologic information of the recent geologic map [8], in addition with nine NASA Drillings [6], and up to 40 Bavarian Environment Agency drillings in ArcGIS (ESRI) and RockWorks14 (RockWare) to interpolate the elevation of the lower contact plane ("paleo-surface") and the contact between the Bunte breccia and the overlain Suevite deposits to reconstruct the Bunte Breccia thickness variation outside of the Ries impact crater [7]. Our final interpolation results of the paleo-surface and Bunte Breccia top surface provide an increasing Bunte breccia thickness with increasing distance from the crater center. The ejecta thickness distribution clearly deviates from a steady decrease with radial range [7]. The interpolation results show that the Bunte Breccia decreases beyond the crater rim to a few meters at 16 km (1.23 crater radii) forming a depression (called moat) followed by a steady increase in thickness with a point of culmination with up to 121.2 m thickness at a radial distance between 18.80 and 27.55 km (1.45–2.12 crater radii) forming a massive concentrically trending ridge (called rampart). Beyond this ridge the Bunte Breccia thickness rapidly decreases to less than 40 m. The farthest extent of Bunte Breccia is situated at 43.64 km (3.36 crater radii) from the crater center [7]. The observed variation characteristics of the Bunte Breccia thickness outside the Ries impact crater is comparable to morphology characteristics of double-layered ejecta craters on Mars that show elevated rampart features at distances of ~ 2.5 crater radii from the crater center (e.g. complex Martian DLE crater Steinheim) [9].

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