STRUCTURAL UPLIFT AND EJECTA MEASUREMENTS ALONG THE CRATER WALL OF AN UNNAMED 16 KM-DIAMETER COMPLEX IMPACT CRATER ON MARS. S. Sturm[1], T. Krüger[1], and T. Kenkmann[1], [1]Institute for Earth and Environmental Sciences – Geology, Albert-Ludwigs-Universität Freiburg, Germany (sebastian.sturm@geologie.uni-freiburg.de).

Introduction: The distinct elevation of crater rims, observed at large craters on Earth, Moon, and Mars, is in contradiction to the gravitational collapse of the rim region of complex impact craters. This work is aimed to understand the causes of the elevated crater rims by quantification of the amount of structural uplift and ejecta thickness in crater rims. While the raised rim in simple craters is the result to one half of the thickness of the proximal ejecta blanket (overturned flap) and to the other half of plastic deformation and dike injection in the underlying target [1, 2, 3], the cause of elevated topographies of final crater rims [4] in complex craters is less obvious: In complex craters the thick, proximal ejecta blanket is situated well inside the final crater where ~50% of ejecta is deposited [2, 5, 6].

In the crater wall of a pristine, 16 km diameter, complex impact crater (21.52°N, 184.35°E), situated in Marte Valles on Mars, columnar lavas were discovered on high-resolution images (HiRISE) [7]. These lavas exhibit the features of terrestrial columnar basalts and have flow thicknesses of up to 30 to 40 m [7]. We used the presence of these exposed columnar lavas along the crater wall to investigate the dip of target rocks and to distinguish between autochthonous bedrock and overlying ejecta. We investigated two distinct areas around the crater wall that allow us to trace the boundary between uplifted bedrock material (exposed as columnar lavas) and superposed ejecta material. We calculated the structural uplift and the strata dip of the exposed bedrock, and the thickness of the ejecta situated on top. As a final result we determined the proportion of structural uplift and ejecta material that together build-up the total amount of the final crater rim of this Martian complex impact crater.

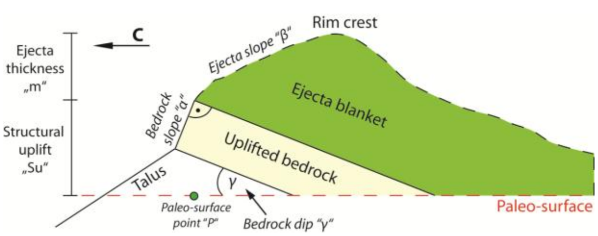

Fig. 1: Schematic sketch of the crater wall region (C = crater center).

Methods: For our analyses we combined high-resolution images and digital elevation models (HiRISE and CTX, resolutions of 1 m and 6.2 m, respectively) to analyze the crater wall of a complex martian impact crater. First we calculated the elevation of the paleo-surface (***Fig 1, red dashed line***) of the crater to receive a reference for the calculation of the amount of structural uplift "*Su*" of the exposed and uplifted bedrocks. The paleo-surface was calculated by linear interpolation between two points situated beyond the continuous ejecta blanket, whose connection line goes through the crater center and the boundary point between the uplifted bedrock and the superposed ejecta, to exactly calculate the paleo-surface elevation for the exposed boundary location point "*P*" (***Fig. 1, green dot***). In a next step we measured the thickness of the superposed ejecta material "*m*" (***Fig 1***). Third we calculated the bedrock strata dip "γ" of the exposed columnar lavas. For this calculation we assumed that an orthogonal relationship between the columnar lava slope "*α*" and their dip "γ" exists (***Fig. 1***). In a final step we calculated the ratio of the structural uplift and ejecta thickness that together build-up the total amount of the elevated crater rim.

Results: The measured and calculated results for two representative regions (Mask 1 and Mask 2) along the crater wall are illustrated in ***Tab. 1***. The mean rim height is 375.75 m. Of this 57.44 % (233.88m) is built-up by an uplift of bedrock material, exposed as columnar lavas, and 42.56 % (141.87 m) are formed by superposed ejecta material**.**

Tab. 1: Calculation results of two representative areas around the crater wall that show distinctive boundaries between uplifted bedrock (exposed as columnar lavas) and superposed ejecta material (see *Fig. 1*):

	Mask 1	Mask 2
Paleo-surface elevation "*P*" [m]	-3490.54 ± 3	-3476.89 ± 2
Structural uplift "*Su*" [m]	220.83 ± 66	246.92 ± 15
Ejecta thickness "*m*" [m]	178.21 ± 83	105.52 ± 17
Total rim height [m]	**399.04 ± 46**	**352.44 ± 9**
Bedrock slope "*α*" [°]	61.03 ± 6	60.50 ± 9
Ejecta slope "*β*" [°]	31.31 ± 4	31.41 ± 4
Bedrock dip "*γ*" [°]	28.97 ± 6	29.50 ± 9
Structural uplift content [%]	**56.25 ± 18**	**58.63 ± 6**
Ejecta content [%]	**43.75 ± 18**	**41.37 ± 6**

Discussion and Conclusion: Based on empirical relationships compiled by Melosh (1989) and Steward and Variant (2006) 16 km diameter complex martian impact crater are expected to have total rim heights of 343 m, and 335 m, respectively. Our mean rim height measurements of 375.55 m (Mask 1 and Mask 2) slightly exceed these calculations [2, 8]. This suggests that the selected rim regions (Mask 1 and Mask 2) show a relatively low degree of erosion. Nevertheless, the varying slope values of uplifted bedrock material (α) compared to the superposed ejecta material (β) seems to indicate different erosion resistivities of these two lithologies (***Tab. 1, Fig. 2b***). The uplifted bedrock rock units (exposed as columnar lavas) have steeper slope angles in contrast to the more un-solidified ejecta material that shows stronger erosion susceptibility indicated by shallower slope angles (***Tab. 1***, ***Fig. 2b***). The different slope values are a helpful tool to distinguish between the more resistant uplifted bedrock material in contrast to the more friable ejecta material on top at this crater wall.

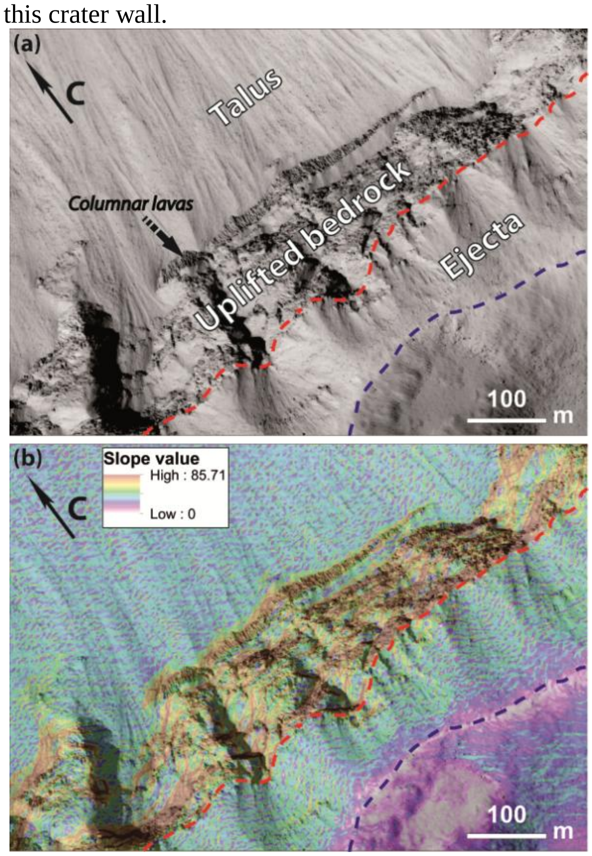

Fig. 2: (a) Crater wall region showing the different units that build-up the total amount of the crater rim (PSP_006774_2020), (b) superposed slope map of a crater wall region (DTEEC_006774_2020_007341_2020) (red dashed line = boundary between uplifted bedrock and overlain ejecta; blue dashed line = rim crest; C = crater center).

Our rim height measurements of this martian complex impact crater show that we have even at a distance of 7.8 km from the crater center a substantial structural uplift of up to 233.88 m of the target material that builds up to 57.44 % of the total amount of the recent elevated rim. Steward and Valiant (2006) calculated a structural uplift of 215.83 m at a distance of 7.8 from the crater center for a complex martian impact crater with a diameter of 16 km [8].

Transient crater size calculations for this study crater with a final radius of 8 km predict a transient crater radius of 6.9 km [9, 10]. The uplifted bedrock material of the study crater is exposed 7.8 km from the crater center and thus situated in a distance of 0.9 km beyond the transient crater cavity (***Fig. 2***). It seems to be unlikely that only plastic deformation and dike injection in the underlying target material contribute to the total amount of the structural uplift at this distance. Under these circumstances an additional mechanism, such as reverse faulting during the excavation stage, is necessary to provide the measured structural uplift at this distance beyond the transient crater rim. However, our measurements show that for complex impact craters the structural uplift seems to be more dominant than the amount of superposed ejecta at the final crater rim to build-up the total amount of the final crater rim.

Similar results were derived for complex lunar craters [11, 12]. In a next step our dataset and analyses will be extended to more and larger complex impact craters that show distinctive and exposed boundaries between uplifted bedrock and ejecta material along their crater wall.

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