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Why do complex impact craters have elevated crater rims?

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Most of the complex impact craters on the Moon and on Mars have elevated crater rims like their simple counterparts. The raised rim of simple craters is the result of (i) the deposition of a coherent proximal ejecta blanket at the edge of the transient cavity (overturned flap) and (ii) a structural uplift of the pre-impact surface near the transient cavity rim during the excavation stage of cratering [1]. The latter occurs either by plastic thickening or localized buckling of target rocks, as well as by the emplacement of interthrust wedges [2] or by the injection of dike material. Ejecta and the structural uplift contribute equally to the total elevation of simple crater rims.

The cause of elevated crater rims of large complex craters [3] is less obvious, but still, the rim height scales with the final crater diameter. Depending on crater size, gravity, and target rheology, the final crater rim of complex craters can be situated up to 1.5-2.0 transient crater radii distance from the crater center. Here the thickness of the ejecta blanket is only a fraction of that occurring at the rim of simple craters, e.g. [4], and thus cannot account for a strong elevation. Likewise, plastic thickening including dike injection of the underlying target may not play a significant role at this distance any more.

We started to systematically investigate the structural uplift and ejecta thickness along the rim of complex impact craters to understand the cause of their elevation. Our studies of two lunar craters (Bessel, 16 km diameter and Euler, 28 km diameter) [5] and one unnamed complex martian crater (16 km diameter) [6] showed that the structural uplift at the final crater rim makes 56-67% of the total rim elevation while the ejecta thickness contributes 33-44%. Thus with increasing distance from the transient cavity rim, the structural uplift seems to dominate. As dike injection and plastic thickening are unlikely at such a distance from the transient cavity, we propose that reverse faulting induced by radially outward directed maximum stresses during the excavation flow may be responsible for the elevation of complex crater rims. This hypothesis is tested at terrestrial craters whose apparent crater rims are often confined by circumferential faults [7].

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