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Structural uplift and ejecta thickness of lunar mare craters: New insights into the formation of complex crater rims

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Most complex impact craters on solid planetary surfaces throughout the Solar System exhibit elevated crater rims similar to the elevated crater rims of simple craters. In principal the final elevation of the crater rim is due to the deposition of ejecta on the structurally uplifted bedrock of the pre-impact surface. For simple craters the elevated crater rim is due to two well understood factors: (i) Emplacement of the coherent proximal ejecta material at the transient cavity rim (overturned flap) [1]. (ii) Structural uplift of the pre-impact surface in the proximity of the transient cavity [1, 2]. The amount of structural uplift at the rim of simple craters is due to plastic thickening of the target rock, the emplacement of interthrust wedges and/or the injection of dike material in the underlying target [1, 2, 3, 4]. Both factors, (i) and (ii), are believed to equally contribute to the structural uplift of simple craters.
Larger craters have complex morphologies and the crater′s extent may considerably exceed that of the transient cavity due to gravity-driven adjustment movements. For instance, the Ries crater′s final diameter is twice of its transient cavity size. It is expected that both ejecta thickness and structural uplift decrease with increasing distance from the rim of the transient crater. For lunar craters the continuous ejecta extends up to 2 crater radii from the crater center. The ejecta blanket thickness ET at the rim crest of the transient crater (which is inside the final crater) is a function of the distance r from the crater center, with RT as the radius of the transient crater [2, 6, 7] and is expressed by the following function:
(1) $ET = 0.033\ RT\ (r/RT)^{-3.0}$ for $r \geq RT$ [5, 6]
The structural uplift is largest at the transient cavity rim and gets rapidly smaller with increasing distance to the crater center and disappears after 1.3 – 1.7 crater radii [1]. These circumstances raise the question, how elevated rims of complex craters form?
Based on High-resolution imagery from the Lunar Reconnaissance Orbiter Camera [8] we studied several complex lunar craters and precisely measured their total rim height, the amount of structural uplift and the ejecta thickness along the final crater rim. Our detailed investigation is focused on the lunar mare craters Bessel (16 km), Euler (28 km), Kepler (32 km), Harpalus (39 km) and Bürg (41 km).
A mean of 70.6% of the rim height of the final crater of the five lunar craters is due to the structural uplift of the target. The rest is contributed by the ejecta thickness (29.4 %). These results are in good agreement with previous studies [1]. The final crater diameter is given as a multiple of the transient crater diameter (DT) for all investigated craters: Bessel (1.01DT), Euler (1.16DT), Kepler (1.21DT), Harpalus (1.40DT) and Bürg (1.10DT). The transient crater diameter increases with the diameter of the final crater. Currently we are assessing the mechanism of a structural uplift at larger distance to the transient cavity rim. The structural uplift of the crater rim only by dike injection and plastic deformation in the underlying target material seems unlikely at distances >1 km from the transient crater cavity. Other mechanisms, like reverse faulting, beginning in the excavation stage of crater formation, could be responsible for additional structural uplift of the crater rim. Nevertheless, our results show that structural uplift is a more dominant effect than ejecta emplacement for complex impact craters.

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