Excavation of crust and mantle materials in lunar basin formation – insights from numerical modeling

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Impact basins form via the growth of a deep, bowl-shaped transient crater followed by a complex collapse process to produce the final basin morphology. The collapse of the gravitationally unstable transient crater occurs by a combination of inward motion of the crater walls and uplift of the crater floor, both of which depend sensitively on the shear strength and temperature of the crust and upper mantle [1-3]. During crater formation lower crust and upper mantle materials can become exposed on the surface in one of two ways: (i) as part of the ballistic ejecta that is deposited outside the transient crater rim and (ii) as part of the outwardly collapsing central uplift that is thrust up over the inwardly collapsing transient crater rim.

The formation of lunar impact basins was modeled using the iSALE-2D hydrocode [4-6], for a range of target properties typical for the Moon at the time of lunar basin formation. Impact simulations used nine different target temperature profiles [7] and three pre-impact crustal thicknesses (30, 45, and 60 km). All impact simulations used projectiles that were 15, 30, 45, 60 or 90-km in size, impacting the Moon at 10 or 17 km/s, which yield the entire size range of lunar impact basins except the South Pole-Aitken basin. The methodology employed was similar to that in our previous work [1,2].

The analysis of lunar basin subsurface morphology produced by the numerical modeling suggests that the target temperature affects both the final basin size and the extent of the crustal thinning, mantle uplift, thickening of the crust surrounding the mantle uplift, and thickness of the crustal cap that covers up the mantle uplift. This work focuses on the extent and locations of the crustal overturn and possible mantle exposures at the surface of the Moon, for different size lunar basins that could have formed in different crust-mantle temperature gradients and a range of lunar crustal thickness.

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