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Complex crater formation: Insight from Numerical Modeling

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The formation of complex craters is a complex mechanism that is not fully understood since standard strength models fail to explain the collapse at the observed simple-complex transition diameter where a significant change in the depth-to-diameter ratio occurs. One of the most successful approaches to explain temporary strength degradation is Acoustic Fluidization (AF), which is based on the assumption that the transient cavity is surrounded by fractured rocks. Such a system of debris are excited by acoustic waves in the wake of an expanding shock wave, and behaves like a Bingham fluid with a Bingham cohesion that depends on the amplitude of the acoustic wave, which is a function of time as the acoustic wave attenuates.

This study aims at a better understanding of the mechanics of complex crater formation, by constraining AF parameters by means of morphometric crater parameters. We present the results of a systematic numerical modeling study with the iSALE shock physics code, where we tested the effect of the AF parameters on crater morphometry over a broad range of sizes of complex impact structures. Furthermore, we introduce preliminary results on the correlation between the final and transient crater diameter.

We found that the decay time is the responsible parameter for the largest variations in the final crater morphometry (e.g., diameter and depth), and whether or not the central uplift develop. The higher values of decay times best reproduce the observed trend in the lunar crater record, and favor the uplift of the central peak. The corresponding impact structures have a depth-to-diameter ratio lower than $\sim$0.8.

Finally, we derive from the model series that shows the best agreement with the observed morphometric parameters relationship between final and transient crater diameter. Other sets of AF parameters result in variations up to 20% for the ratio between the transient and final crater diameter. With respect to published scaling laws based on observations we find generally lower transient-to-final crater diameter ratios in our models.