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Impact crater formation in mixed crystalline and sedimentary targets: Insight from numerical modelling

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A phenomenological model for the formation of impact craters in crystalline targets exists, based on decades of geological, geophysical, experimental and theoretical study. An impact excavates a deep, bowl-shaped cavity that subsequently collapses under gravity to form the final crater morphology. Numerical simulations have verified this model, to a large extent, by reproducing the final crater morphology of many large terrestrial craters, and the size-morphology progression of lunar impact craters, with the proviso that the apparent strength of the target rocks is much weaker than typical rock mechanics experiments indicate.

Despite the success of this standard model, there are many terrestrial craters for which it is difficult to reconcile numerical model results with observed crater structure. This is due in large part to the influence on the cratering process of target rock type. Many terrestrial craters are formed in mixed sedimentary and crystalline targets, where the sedimentary rocks can be anything from very weak, poorly-lithified, water-saturated soils, to strong, dry, non-porous limestones or dolomites. We investigate the effect of sedimentary rock strength and thickness in simulations of terrestrial impact events. We focus on mid-sized (15-40 km diameter) complex craters, of which there are several examples of impacts into mixed targets of varying sediment type and thickness (e.g. Ries, Haughton, Chesapeake Bay). Our results suggest that the presence of a sedimentary layer somewhat weaker than the underlying crystalline basement can help reconcile the standard model of crater formation with observation at terrestrial impact structures. In our simulations, impact-related deformation is enhanced in the sediments leading to a broader crater than would be the case in a purely crystalline target. An important conclusion from this is that the diameter of an impact crater formed in a mixed target can be a misleading measure of impact energy.