Why do impact craters collapse?

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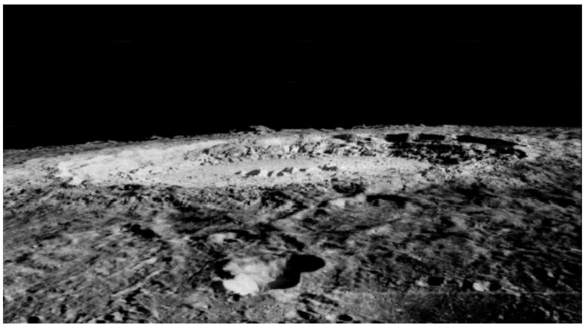

Large impact craters, such as the 93-km diameter Copernicus (pictured), are extremely shallow, with depth-to-diameter ratios much less than 1:5, the ratio observed for all small craters. Based on remote sensing and geological observations, it is thought that craters above a certain size are gravitationally unstable and rapidly collapse to a shallower, stable state. In the process, internal topographic features, such as central peaks and peak rings, also characteristic of large impact basins, are formed inside the crater margin. However, the effective strength of the target rocks necessary for craters to collapse is orders of magnitude weaker than quasi-static measurements of rock strengths. Hence, the target rocks must weaken dramatically during large-scale impact-driven deformation [e.g.,1]. An enduring mystery is what causes this dynamic weakening?

Numerical simulations of crater formation are now being performed with sufficient fidelity to resolve individual faults [e.g., 2]. Such simulations suggest that dynamic reduction of friction along faults, which has been observed in laboratory experiments, might explain the apparent reduction in strength during impact. However, both the physical mechanism for fault weakening and how to incorporate multi-scale fault weakening into numerical impact simulations remain uncertain.

The Project The aim of this project is to implement into a state-of-the-art numerical impact model (iSALE) two dynamic fault-weakening models [3,4] and explore their ability to reproduce the observed crater size-morphology progression. A particular challenge will be to develop techniques for predicting and tracking fault spacing and offsets on a range of scales, including scales smaller than the mesh resolution (sub-grid). Simulations results will be compared against new constraints from high-resolution gravity data returned by the GRAIL spacecraft as well as existing morphometric data from fresh lunar craters and geological and geophysical constraints from terrestrial craters.

The successful Candidate will join, and be supported by, a vibrant and dynamic research group with world-class expertise modelling geophysical flows. They will be trained in state-of-the-art numerical methods for simulating hypervelocity impact, impact physics and high-performance computing. The candidate will have the opportunity to develop their career and profile by presenting at international conferences and publishing in high impact journals. Candidates for PhD positions should have a good mathematical background and a good degree in an appropriate field such as earth science, physics, mathematics, computer science or engineering.

[1] Melosh HJ & Ivanov BA (1999) Ann Rev Earth Planet Sci 27:385–415. doi: 10.1146/annurev.earth.27.1.385
[2] Senft LE & Stewart ST (2009) EPSL 287, 3-4: 471–482 doi:10.1016/j.epsl.2009.08.033
[3] Melosh HJ (1996) Nature, 379, 601-606. doi:10.1038/379601a0
[4] Rice, J. R. (2006) J. Geophys. Res., 111, B05311, doi:10.1029/2005JB004006

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