Geophysical Research Abstracts
Vol. 20, EGU2018-16300, 2018
EGU General Assembly 2018

The formation of peak rings in large impact craters

Gareth S Collins (1), Auriol S P Rae (1), Joanna V Morgan (1), and Sean P S Gulick (2)

(1) Department of Earth Science and Engineering, Imperial College, London, UK (g.collins@imperial.ac.uk), (2) Institute for Geophysics & Department of Geological Sciences, University of Texas at Austin, USA.

Peak-ring craters are an important class of impact crater, among the largest found on rocky planetary surfaces. The ring of mountains in the crater centre, which gives the class its name, provides a window into the deep structure and composition of planetary crusts. However, with few terrestrial examples and a lack of direct sampling, debate has surrounded the mechanics of peak-ring formation and their depth of origin.

Two hypotheses for peak-ring formation have evolved in the literature: the "nested crater" model, motivated largely by remote-sensing observations, in which the peak ring originates at shallow depths in the target, and the "dynamic collapse" model, based largely on numerical models, in which the peak ring originates from mid-crustal depths and is uplifted at the base of a collapsing, over-heightened central peak.

The 66 Ma Chicxulub impact crater, Mexico, is one of very few peak-ring impact craters on Earth. It is uniquely well-preserved, but is buried and only accessible through drilling. IODP-ICDP Expedition 364 sampled the Chicxulub peak ring, recovering rocks formed from uplifted, fractured, shocked, felsic basement rocks. The peak-ring rocks are cross-cut by dikes and shear zones and have an unusually low density and seismic velocity. Ongoing analysis of this unique and rich new dataset permits a more thorough assessment of peak-ring formation models and their predictions.

Here we show that simulations of Chicxulub crater formation are in remarkable agreement with both large-scale geophysical observations and fine-scale geological and petrophysical observations from the IODP-ICDP Expedition 364 drill core. Simulation predictions that peak-ring rocks derived from mid-crustal depths and experienced shock pressures of 10-35 GPa are consistent with observations. Moreover, high-fidelity analysis of the stress-strain-time path of peak-ring rocks reveals a complex, multi-stage deformation history in close correspondence with that inferred from the cross-cutting dikes and shear zones. The match between simulations and observations provides strong support for the dynamic collapse model of peak-ring formation and its application to large craters on other planets. The Chicxulub asteroid impact released $\sim 2.7 \times 10^{23}$ J energy (equivalent to 64 million Mt TNT), forming an approximately 90-km wide, 30-km deep hole in the crust that collapsed within 10 minutes to produce the $\sim$ 200-km diameter crater observed today. New 3D simulations of Chicxulub crater formation also provide new insight into the direction and trajectory angle of the impact.