Geophysical Research Abstracts
Vol. 20, EGU2018-10873, 2018
EGU General Assembly 2018

Quantitative Geological Predictions of the Dynamic Collapse Model of Peak Ring Formation: Comparisons with Observations from the Chicxulub Impact Structure

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Large impact structures possess internal topographic rings known as peak rings. The formation of these structures has been described by the Dynamic Collapse Model of peak ring formation, where an initially bowl-shaped transient cavity gravitationally collapses inwards and upwards to form a central uplift which then collapses outward to form a peak ring. This process requires a substantial and transient reduction in strength of impacted rocks. While the mechanism of this weakening is uncertain, the model has had considerable success at reproducing the morphology and sub-surface structure of peak-ring craters. The Dynamic Collapse Model makes quantitative predictions of both the petrophysical properties and the impact-related geological history of impacted rocks. However, until recently there have been no direct samples of an unequivocal peak ring against which to compare. Recent scientific drilling by IODP-ICDP into the Chicxulub impact structure provides the first samples of a peak ring, and consequently, a unique opportunity to test those predictions.

Here, we present predictions from numerical simulations of: shock magnitude and direction, micro-fracture orientations, deformation history, impact-induced porosity, and the crater's gravity anomaly. The numerical predictions are then compared with observations from the recovered core, and from pre-expedition geophysical surveys. Overall, our results show a remarkable consistency between the predictions of the numerical simulations with geological and petrophysical observations.

Our results provide further compelling support for the Dynamic Collapse Model of peak-ring formation. Additional implications of this work include: absolute constraints on the strain and stress conditions required for specific deformation textures, predictions of permeability anisotropy across large impact structures, and a greater understanding of the mechanism that causes transient weakening during crater collapse.