# THE SCHRÖDINGER BASIN AND PEAK-RING FORMATION ON THE MOON: IMPLICATIONS FOR THE EARTH'S CHICXULUB CRATER

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**Introduction:** The peak ring of the Moon's ~320 km diameter Schrödinger basin rises 2.5 kilometers above a basin floor of impact melt and melt-bearing breccias (e.g., [1–3]). Schrödinger basin and its peak ring are the youngest, best preserved impact structures of their size on the Moon and are perfect proxies for Earth's deformed, eroded, and buried basins (Vredefort, Sudbury, and Chicxulub; e.g., [4]).

**Geologic Mapping:** Geological mapping indicates the peak ring is composed of hectometer- to kilometer-size sections of anorthositic, noritic, and troctolitic rocks, which we infer to be from the mid- to lower-crust of the Moon rather than its upper mantle. The peak ring is cross-cut by a series of faults with radial, circumferential, and oblique orientations. Movements along those faults juxtaposed lithologies from different depths, with offsets of at least a kilometer, producing a series of complex topographic offsets. Individual blocks of rock exist within larger outcrops of the anorthositic, noritic, and troctolitic lithologies suggesting fracturing and comminution of crustal basement lithologies on a scale of meters and possibly smaller (the limit of resolution being 0.5 m in Lunar Reconnaissance Orbiter Camera-Narrow Angle Camera images). Fragmented rocks, with reduced friction and cohesion between those rock fragments, would have enhanced flow of the crustal lithologies as the central uplift collapsed into nappe-like structures that were displaced outward towards the margin of the transient crater, while those transient crater walls were collapsing to produce a much larger diameter peak-ring basin.

**Numerical Modeling:** To further evaluate the interpreted source depth and mode of emplacement of peak ring lithologies, iSALE hydrocode simulations of the impact were conducted for a 25 km projectile, 15 km/s impact velocity, and 20- and 40-km thick lunar crust that reflect variations and uncertainties in gravity models, producing final basin diameters similar to that observed on the Moon. Because of rheological differences between crust and mantle, crustal thickness affects the magnitude of uplift, amount of outward transport, and, thus, final radius of the peak ring. Peak ring source depths are <30 km and entirely crustal (not mantle). The source depths of peak ring materials are less in the thin-crust case. The simulations demonstrate peak ring material is not composed of material that rose from a depth equivalent to the depth of the transient crater (e.g., 62.5 km in the case of the model with a 40 km thick crust). Rather, it was produced from material in the central uplift that collapsed and was then displaced radially outward in nappe-like structures. Shock pressures that affected peak ring materials range from 10 GPa up to melting (50–80 GPa), but are dominantly <25 GPa, the threshold for producing maskelynite.

**Discussion:** These results have implications for the ongoing International Ocean Discovery Program (IODP) Expedition 364 drilling project into the buried peak ring of the Chicxulub impact crater. The geologic mapping and numerical modeling above indicate peak rings are not simple anticlinal structures that preserve crustal sequences as a function of depth (implied by a nested melt-cavity model [5]), but are instead recumbent fold structures with overturned crustal sequences. The hydrocode simulations also indicate, however, that the structural and paleodepth sequence seen in a single borehole depends on its radial position in the peak ring.

Our observations of the spectacularly exposed peak ring of Schrödinger provide an additional level of lithologic detail not evident in the hydrocode simulations. The kilometer-scale fault displacement exposed at the top of the peak ring of Schrödinger basin indicates that material of different paleodepths can be juxtaposed, implying two outcomes: That the faults are a modest modification of the nappe-like structure and that an overturned sequence at Chicxulub may be evident if the IODP borehole is sufficiently deep; alternatively, that those faults are a near-vertical product of the collision of the outward flowing collapsing peak and the inward flowing modification zone (e.g., as in [4]), in which case a borehole could encounter multiple truncating faults rather than an overturned sequence. The boulder-rich outcrops seen in the Schrödinger peak ring suggest fracturing of uplifted rocks may occur on a much smaller scale than any large faults in the Chicxulub peak ring. Complementary numerical modeling also suggests that those materials will be dominated by relatively low levels of shock-metamorphism.

**References:** [1] Shoemaker E. M. et al. 1994. *Science* 266:1851–1854. [2] Mest S. C. 2011. *Geological Society of America Special Paper* 477:95–115. [3] Kramer G. Y. et al. (2013) *Icarus* 223:131–148. [4] Grieve R. A. F. et al. 2008. *Meteoritics & Planetary Science* 43:855–882. [5] Head J. W. 2010. *Geophysical Research Letters* 37: doi:10.1029/2009GL041790.