GRAIL GRAVITY OBSERVATIONS OF THE TRANSITION FROM COMPLEX CRATERS TO PEAK-RING BASINS ON THE MOON: IMPLICATIONS FOR CRUSTAL STRUCTURE AND IMPACT BASIN FORMATION. David M.H. Baker[1], James W. Head[1], Roger J. Phillips[2], Gregory A. Neumann[3], David E. Smith[3,4], and Maria T. Zuber[3,4]. [1]Department of Geological Sciences, Brown University, Providence, RI 02912 USA, Email: David_Baker@brown.edu; [2]Planetary Science Directorate, Southwest Research Institute, Boulder, CO 80302 USA; [3]Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771 USA; [4]Department of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA 02139 USA.

Introduction: The onset of impact basins on the Moon and other planetary bodies occurs with the appearance of two concentric topographic rings, forming peak-ring basins [1]. Recent lunar gravity measurements by the Gravity Recovery and Interior Laboratory (GRAIL) mission [2] now provide the opportunity to analyze the gravity and crustal structure of craters near the onset of impact basins in greater detail. We use these gravity measurements, combined with our morphometric observations [3-5] to investigate the evolution of the crust/mantle structure in the transition from complex craters to peak-ring basins on the Moon.

Methods: We measured the topography (LOLA), free-air and Bouguer gravity anomalies (GRAIL JGGRAIL_660C6A), and Moho relief (Model 1 of [6]) for peak-ring basins, protobasins, and complex craters ≥100 km in the catalogs of [3,5]. Datasets were expanded from spherical harmonic degrees 16 to 310 and in 4ppd grids. For each dataset, azimuthally averaged radial profiles were measured from the basin center to three crater/basin radii. The gravitational effects of mare fill were not removed here; however, our estimates indicate that mare does not substantially affect the overall trends.

Free-air gravity anomalies (FAAs): Lunar mascon basins [7] are characterized by positive central FAAs. Eleven peak-ring basins (250-580 km in diameter) show positive central FAAs. Positive central FAAs are generally absent in complex craters and protobasins, suggesting that the mascon-forming processes begin to dominate over lithospherically-supported topographic effects following the onset of peak-ring basins (~200 km).

Bouguer gravity anomalies (BAs): All peak-ring basins show a positive, central BA that is ringed by an annulus of negative BAs. The radius of the positive BA correlates well with the radius of the interior peak ring. The negative BA annulus reaches a minimum midway between the peak ring and rim crest and extends outward to near the rim crest. Protobasins and most complex craters do not exhibit this regular BA pattern. Instead, BAs are more irregular and not clearly tied to surface morphology [8]. The absolute magnitudes of the maximum central BA and minimum annular BA increase proportionally for peak-ring basins, with complex craters and protobasins following a different trend (Fig. 1)

Moho relief and crustal thickness: From the models of [6], we interpret the central positive BAs in peak-ring basins to represent central uplifts of the crust-mantle boundary and thinned crust confined within the peak ring. This mantle uplift is bounded by an annulus of thickened crust, producing the observed ring of negative BAs. Since strongly circular, central, positive BAs are generally absent in complex craters and protobasins, we suggest that mantle uplift is relatively minor or absent at these crater sizes.

Implications for the crater to basin transition: Our observations show that the formation of central positive Bouguer anomalies and associated negative BA annuli are fundamental characteristics of all basins (peak-ring basin to multi-ring basin [9]) on the Moon. Further, mascons occur down to diameters of at least 250 km, indicating that mascon-forming processes [10,11] are effective for small basins. The transition from complex craters to peak-ring basins not only involves a change in interior landforms (central peak to peak ring) but also a strong change in character of crustal and mantle structure. The coincidence of the onset of substantial mantle uplifts and crustal thickening with the onset of peak rings and the correlation of the radius of the central mantle uplift with the radius of the peak ring is highly suggestive that these features are intimately linked. These gravity observations and recent morphometric observations have important implications for models of the formation of peak rings and should together act as an observational framework for understanding impact basin formation on the Moon and other planetary bodies.

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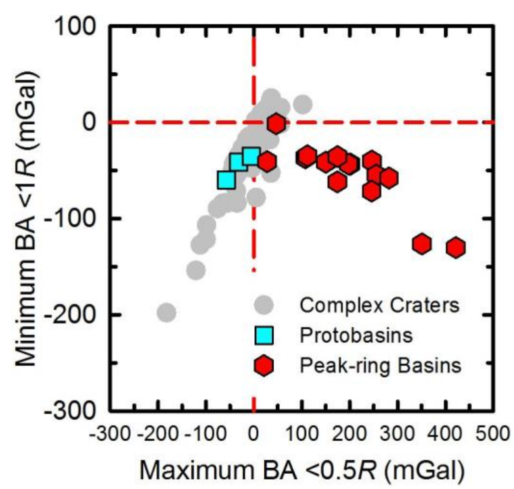

Fig. 1. Trends of the minimum Bouguer gravity anomaly (BA) within 1*R* (where *R* is crater/basin radius) versus the maximum BA within 0.5*R* for peak-ring basins, protobasins, and complex craters. For peak-ring basins, this plot shows the trend in the minimum value of the negative BA annulus versus the central BA maximum (both have linear trends with rim-crest diameter for peak-ring basins).