however, the uplifted periphery of the melt cavity remains as the only topographically prominent feature, resulting in the formation of a peak ring (Head, 2010). At smaller crater sizes, and hence shallower depths of melting, it is still possible for a small central peak to rise through the melt cavity, accounting for the central-peak and peak-ring combinations that are observed in protobasins (Cintala and Grieve, 1998; Baker et al., 2011).

One of the benefits of the nested melt-cavity model is that it makes specific predictions that may be compared with the ring and rim-crest diameter systematics of basin catalogs. Analysis of a recently updated basin catalog for Mercury (Baker et al., 2011) showed many first-order consistencies with the predictions of the nested melt-cavity model, particularly in the observations of (1) the surface density of peak-ring basins on the terrestrial planets, (2) the continuum of basin morphologies between protobasins and peak-ring basins, and (3) the power-law trend of peak-ring basins. Our analysis of the new lunar catalog confirms many of these consistencies with the nested melt-cavity model, providing additional support to the importance of impact melting in forming peak rings.

It is important to note that the geometries of impact melting and the transient cavity derived from theoretical calculations are only static representations of a very dynamic process. In reality, at no time during the impact event are these geometries fully achieved, and the dynamics of crater formation certainly affects how the melted portions of the displaced zone evolve and are distributed within the target material with time. However, these details of the cratering process are still poorly understood and modeled. More certain has been various analytical and numerical estimates of the volume and depths of melting (Grieve and Cintala, 1992; Pierazzo et al., 1997; Barr and Citron, 2011), which appear generally consistent with each other and with estimates of melt volumes obtained from field observations of terrestrial impact structures. Considering the geometrical assumptions and uncertainties involved with a static model for the generation of impact melt, our presentation of the nested melt-cavity model should be viewed as a first-order attempt in understanding the effects of impact melting on the morphology and development of peak-ring basins. While we find many consistencies between the model and our analysis of the basin catalogs for the Moon and Mercury, more complex and dynamic melt-zone geometries are probably more realistic, and future refinements to this model will be necessary, especially in improving dynamical simulations of impact melting during large impact events.

As stated above, Mercury has the largest number of peak-ring basins per unit area of the terrestrial planets, with the Moon having a factor a two fewer peak-ring basins based on our new lunar basin catalog (Table 1). Under the nested melt-cavity model, the difference in the surface density of peak-ring basins between Mercury and the Moon may be explained by differences in mean impactor velocities on the two bodies. Because of the higher mean impact velocities on Mercury ($\sim$40 km/s compared with $\sim$20 km/s on the Moon), impactors of a given size will produce approximately twice as much melt on Mercury as on the Moon (Grieve and Cintala, 1992). As a result, peak-ring basin formation will be more effective on Mercury for smaller impactors, which are more numerous than larger impactors (Head, 2010). If similar impactor size-frequency fluxes for the inner planets are assumed (Strom et al., 2005), the number of protobasins and peak-ring basins per area should increase with the mean impact velocity at the planet. From the new basin catalogs (Table 1), there appears to be a slight correlation between the number of peak-ring basins per unit area and the planet's mean impact velocity (Fig. 7B) and an even stronger correlation with gravitational acceleration and mean impact velocity combined (Fig. 7C). These correlations are consistent with the predictions of the nested melt-cavity model and the correlations in onset diameter (Fig. 6), which suggest that both gravity and velocity are likely important in determining the onset diameter and also surface density of peak-rings on the terrestrial planets (see discussion on onset diameter, below). The low density values for Mars and Venus are likely to be due to planetary resurfacing events; if the complete basin records for Mars and Venus were available, the correlation between the number of peak-ring basins and mean impact velocity might further be strengthened.

The nested melt-cavity model also predicts that there will be a continuous progression of impact basin morphologies in the transition from complex craters to peak-ring basins. Under that model, the influence of increasing melt volume and depth of impact melting becomes more important with increasing basin size. In the transition from protobasins to peak-ring basins, uplifted central peak material is suppressed by increasing depth of impact melting, and the uplifted periphery of the melt cavity emerges as the dominant interior morphology (Cintala and Grieve, 1998). This results in a continuum of basin morphologies between protobasins and peak-ring basins, which is very apparent from our new measurements of ring and rim-crest diameters on the Moon (Figs. 4 and 5). The continuous, non-linear trends observed from plots of ring/rim-crest ratios are very consistent between the Moon, Mercury, and Venus (Fig. 5). Ring/rim-crest ratios flatten to a near equilibrium value of around 0.5 for peak-ring basins on the Moon (Fig. 5A), slightly larger ratios of 0.5–0.6 for Mercury (Fig. 5B), and much larger ratios ($\sim$0.7) for Venus (Fig. 5C). These differences in shapes of the ring/rim-crest ratios may be controlled by the differences in the physical characteristics of the planet. Under the nested melt-cavity model, these characteristics would include those controlling the production of impact melt, such as impact velocity and target properties such as composition, temperature, and volatiles (Grieve and Cintala, 1997). Ringed peak-cluster basins diverge most from this curved trend for the Moon and Mercury, which can be explained by their similarities with complex craters. Baker et al. (2011) and Schon et al. (2011) suggest that the interior ring in ringed peak-cluster basins may be the result of direct modification of the central portions of the uplift structure. At the relatively small rim-crest diameters of ringed peak-cluster basins, the depth of melting has only begun to penetrate the uplift structure and a melt cavity has not been developed. Rebound of the transient cavity floor therefore results in a disaggregated ring-like array of central peak elements instead of a single central uplift structure or a large peak ring. In this fashion, ringed peak-cluster basins represent unique transitional forms in the process of forming peak rings.

The predictions of a growing melt cavity with increasing basin size may also be compared to the power law trends between ring and rim-crest diameter for peak-ring basins (Fig. 4). Since the solids making up the periphery of the melt cavity eventually translate inward and upward to form the peak ring, relationships between the expected melt volume at a given basin diameter and an estimate of the melt cavity geometry can give a first-order model of how peak-ring diameters should expand with increasing rim-crest diameter. Assuming a hemispherical melt cavity and using the power law relationship between melt volume and diameter of the transient cavity from Grieve and Cintala (1992) in combination with crater modification scaling relationships (Croft, 1985; Holsapple, 1993), Baker et al. (2011) derived a power law expression relating the diameter of the peak ring (D_{ring}) to the diameter of the final crater rim-crest diameter (D_{r}):

$$D_{\mathrm{ring}} = AD_{\mathrm{r}}^{p} \tag{2}$$

where $A = \left(\frac{12}{\pi}c\right)^{1/3}(\alpha^{d})^{1/3}$ and $p = \frac{\beta d}{3}$.

The constants c and d are from the melt volume relation given by Grieve and Cintala (1992), where c depends on target and