Planetary twins? Investigating the formation of asteroid impact basins on the Moon and Mercury

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Abstract. Compared to the Moon, Mercury appears depleted in its number of larger (> 500 km diameter) asteroid impact basins despite its greater size and, consequently, greater gravitational attraction. Fassett et al.[1] suggested Mercury's basin paucity could be due to one of three factors: an observational effect (i.e., data quality), a formational effect (i.e., difference in basin cavity growth) or a later stage post-impact effect (i.e., long-term modification and degradation). In this work, numerical modeling of mercurian basin-forming events was undertaken to directly investigate Fassett et al.'s second suggestion. The iSALE shock physics code was used to simulate basin-forming impacts over a significant diameter range (300 to >1500 km), with particular emphasis placed on the Caloris basin, Mercury's largest identified impact event. Results were compared to a vast data set of lunar basin modeling[2], focusing on impact mechanic parameters such as excavation depth-to-diameter ratio. Non-dimensional pi-scaling relationships were also used to compare the mercurian basins to their lunar counterparts and other craters, covering many orders of magnitude in size. The models suggest that the dynamic phase of basin formation on Mercury is very similar to that on the Moon for all the impact parameters considered. Some slight differences were present and likely a consequence of Mercury's far higher average impact velocity (42 km/s, compared to 20 km/s on the Moon). This work, therefore, suggests that the paucity of large basins on Mercury is likely due to post-impact processes, such as tectonism and volcanism, rather than an inherent difference in basin formation between Mercury and the Moon.

[1] C. I. Fassett et al., *J. Geophys. Res.* 117, E00L08 (2012).
[2] R. W. K. Potter et al., *Geol. Soc. Am. Spec. Pap.* 518, 99 (2015).