MERCURY'S EARLY IMPACT HISTORY AND ITS COMPARISON WITH THE MOON. C. Orgel[1,2], C. I. Fassett[3], G. G. Michael[1], C. Riedel[1], C. H. van der Bogert[4], H. Hiesinger[4]. [1]Freie Universität Berlin, Institute of Geological Sciences, Berlin, Germany, [2]ESTEC, European Space Agency, Keplerlaan 1, Noordwijk 2201 AZ, The Netherlands (csilla.orgel@esa.int), [3]NASA Marshall Space Flight Center, Alabama, USA, [4] Westfälische Wilhelms-Universität, Münster, Germany.

Introduction: Mercury has one of the best preserved impact records in the inner Solar System due to the absence of an atmosphere, but it has much higher rates of surface modification than on the Moon [1-3]. The earliest geological mapping of the planet revealed a variety of important differences from the Moon, regarding the impact basin (D ≥ 300 km) and cratering record, as well as the extensive volcanic plains of Mercury [1-3]. It has been shown [3] that the bombardment history of the terrestrial planets is lunar-like and linked in terms of impactor population(s) and impact rates. Recent studies suggest that Mercury and the Moon had the same early impactor populations based on the similarity of their crater size-frequency distributions (CSFD), however the impact rates on Mercury are higher than on the Moon [4, 5]. Fassett et al. [6] catalogued and characterized the basin population on Mercury using early optical data obtained by the MESSENGER spacecraft and found 46 certain and probable impact basins, as well as 41 tentative.

Research Goals: Here, we re-examine the population, stratigraphy, and sequence of basins on Mercury, as well as their superposed impact crater populations, as we did for the Moon [7]. To analyze the superposed impact crater populations on the mercurian impact basins (D ≥ 300 km), we used the buffered non-sparseness correction (BNSC) [7-9] and buffered crater counting (BCC) [10-11] techniques. We established a new basin catalogue for Mercury. Finally, we investigated the summed CSFDs of Pre-Tolstojan and Tolstojan basins to shed light on the impactor population(s).

Data and Methods: The primary data for this study are optical images mosaicked into a 166 m/pixel global dataset and topography (665 m/pixel) from MESSENGER's Mercury Dual Imaging System (MDIS) and Mercury Laser Altimeter (MLA) (250 m/pixel), respectively. All data products are available from the Planetary Data System (PDS). The data were analyzed in ESRI ArcGIS 10.3.

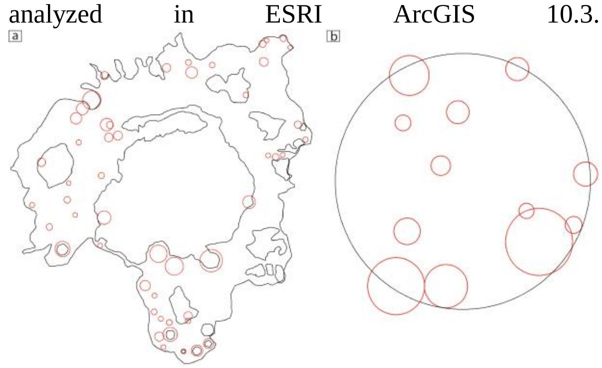

***Figure 1**. Different mapping approaches for the crater measurements. a) Craters (red circles) were counted on basin rim and ejecta deposit remnants (black outline), excluding all areas resurfaced by the smooth plains (e.g. Rembrandt basin). b) All craters were mapped inside the basin cavity (e.g. b102 basin).*

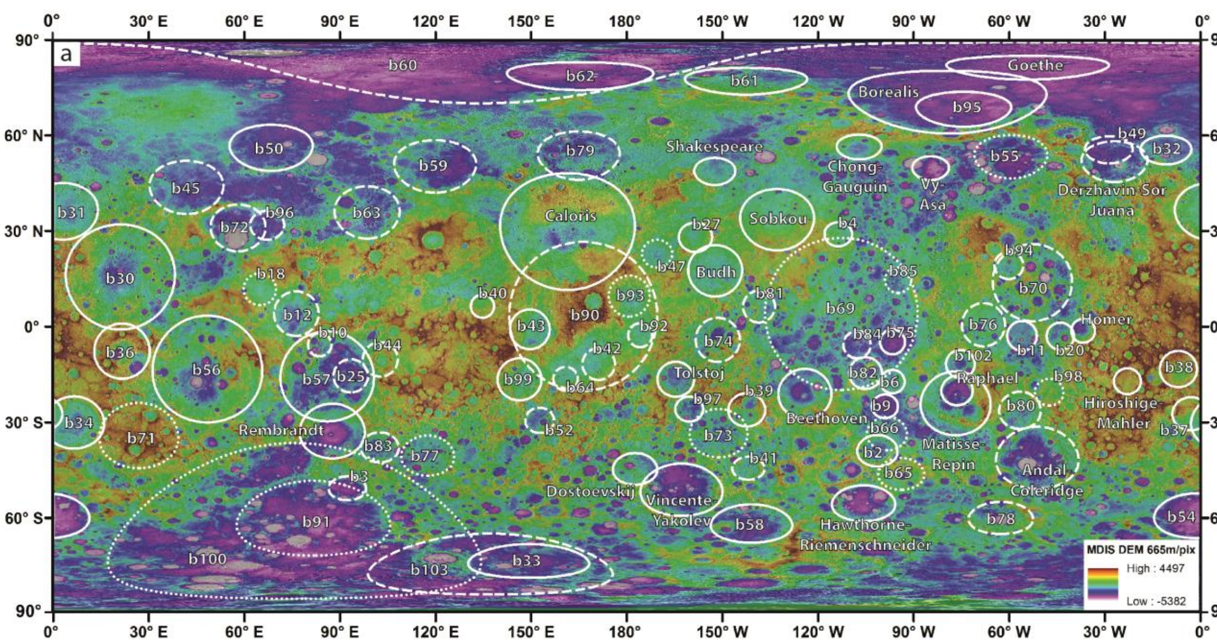

***Figure 2.** Global distribution of basins on Mercury determined from MESSENGER MDIS 166 m/pix data and overlaid on MDIS DEM 665 m/pix resolution data. The basins were classified as (1) certain (solid line), (2) probable (dashed line), and (3) tentative (dotted line). The reference body is a sphere of 2440 km in radius.*

The CraterTools extension in ArcMap [12] was used to map the basins and their related crater populations (D ≥ 25 km). On the basis of completeness of their rims, we classified the basins as either "certain", "probable" or "tentative". We use two different mapping approaches (***Fig. 1***): (1) measuring craters on basin rims excluding areas resurfaced by the smooth plains, and (2) mapping all craters inside basin rims, which only provides a lower limit on the accumulated superposed crater population due to resurfacing within the basins.

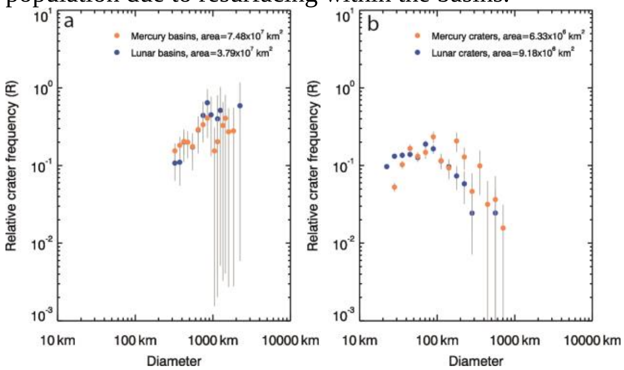

***Figure 3**. Spatial density of (a) large basins (D ≥ 300 km) and (b) craters superposing large basins on Mercury (Pre-Tolstojan, Tolstojan basins and Caloris),and compared to the Moon (Pre-Nectarian, Nectarian and Imbrian basins)[7].*

Results: Altogether, we identified and verified 49 certain, 31 probable, and 14 tentative basins on the surface of Mercury (***Fig. 2***). This is 1.7× more certain and probable basins than in the previous study [6], which was finished before the topography data used here was available. The crater frequencies derived by the BNSC technique provide a correction to the measured frequencies of the smaller craters by an average of 25% compared to BCC. This difference is slightly higher on Mercury than on the Moon, where we measured 24% increase [7].

In contrast to previous studies [5-6], we find that Mercury has slightly higher $N(300)$ crater density (= spatial density of basins with D ≥ 300 km per 10^6 km^2) than on the Moon, but similar $N(500)$ basin densities (***Fig. 3***). The similar $N(500)$ basin density on Mercury and the Moon has substantial implications for the early crustal history of both planetary bodies. This result is likely the consequence of saturation on both surfaces [5]. **Conclusions**: Based on crater densities, we established a relative basin sequence, which proved to be generally in good agreement with relative basin stratigraphy. We estimated that roughly half of the expected basin record is missing, where basins older than Borealis have been concealed by different processes (e.g., higher impact melt production, volcanism, subsequent impacts, and viscoelastic relaxation of basins) (***Fig. 4***) and this finding is in agreement with [13]. In contrast to previous studies, which implied a change in the shape of the CSFDs prior 3.9 Gyr [4, 11, 13], our results are consistent with [7], that in fact only one impactor population bombarded the surface of Mercury.

Acknowledgements: This work was funded by the Deutsche Forschungsgemeinschaft (SFB-TRR 170, subproject A3-3). CIF was supported by a NASA DDAP grant. The manuscript of this abstract is currently (07.01.2020) under revision.

References: [1] Spudis, P. D., and J. E. Guest (1988) in Mercury, edited by F. Vilas, C. R. Chapman, and M. S. Matthews, pp. 118–164, Univ. of Ariz. Press, Tucson. [2] Strom, R. G., and G. Neukum (1988) in Mercury, pp. 336–373, Univ. of Ariz. Press, Tucson. [3] Neukum, G. et al. (2001) PSS, 49, 1507-1521. [4] Strom, R. et al. (2011) PSS, 59, 1960-1967. [5] Fassett et al. (2011) GRL, 38, L10202. [6] Fassett et al. (2012) JGR, 117, E00L08. [7] Orgel et al. (2018) JGR, 123, 748-762. [8] Kneissl, T., Michael, G. G., and Schmedemann, N. (2016) Icarus, 277, 187-195. [9] Riedel et al. (2018) Earth and Space Science, 5, 258-267. [10] Fassett, C. I., and Head, J. W. (2008) Icarus, 195, 6⊢89. [11] Fassett et al. 2012. JGR 117: E00H06. [12] Kneissl, T., van Gasselt, S., and Neukum, G. (2011) PSS, 59, 1243-1254. [13] Marchi et al. (2013) Nature, 499, 59-61. [14] Neumann et al. (2015) Sci. Adv., 1, e1500852.

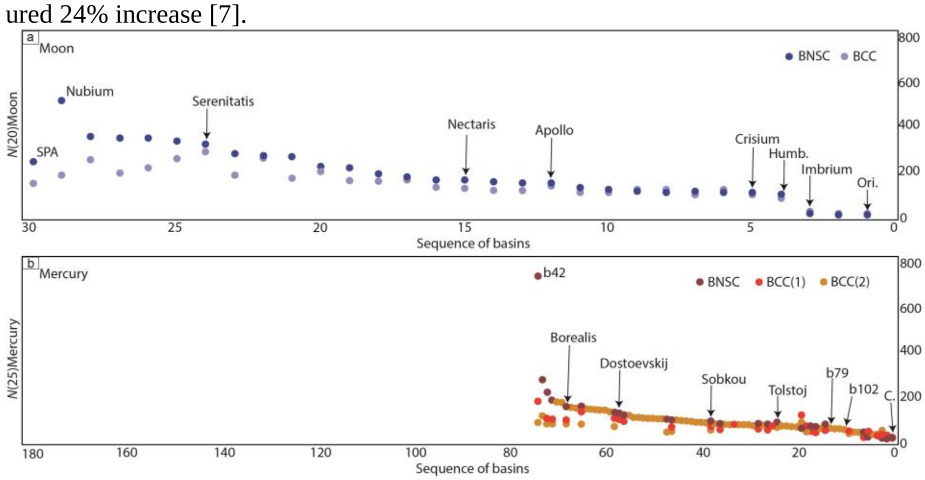

***Figure 4**. Sequence of basin formation on the Moon (a) and Mercury (b). Crater densities derived with (i) BNSC and (ii) BCC techniques with two different mapping techniques on Mercury. Crater densities derived with BNSC commonly show a higher density than with BCC technique on both planetary surfaces. Note the number of lunar and mercurian basins is 30 [7] and 74, respectively. However, we assume that the Moon has 36 lunar basins (including 6 additional basins from [14]) larger than 300 km after the lunar magma ocean solidification, we should observe ~5 times more basins (2.5 times higher crater production rate above 300 km and a factor of 2 greater surface area) to form on Mercury than on the Moon. Consequently, we expect to observe ~ 180 basins on Mercury. Lunar basins are spaced at a 5x interval to compensate for the higher impact rate and larger surface area on Mercury than the Moon; thus, roughly 5 basins should form for every lunar basin.*