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Re-examination of the population, stratigraphy, and sequence of Mercurian basins: Implications for Mercury´s early impact history and comparison with the Moon

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1. Introduction

The Mercury has the second best preserved impact record in the inner Solar System due to the absence of an atmosphere, but a 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 (≥ 300 km) and cratering record as well as 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 term of impactor population(s) and impact rates. Recent studies suggest that Mercury and Moon had the same early impactor populations based on the similarity of the 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 orbital data obtained by the MESSENGER spacecraft and found 46 certain and probable impact basins, as well as a few more uncertain suggested basins. Many of these suggested basins were proposed on the basis of Mariner 10 but could not be verified with the available new data.

In this study, we are re-investigating the number of the mercurian impact basin (≥ 300 km) and their superposed crater populations. Moreover, we will revisit the stratigraphic relationships of basins based on N(20) and N(64) crater frequencies, absolute model ages, and observation data. Finally, we intend to infer potential projectile populations and compare the findings to the Moon.

2. Data and Methods

The primary data for this study are optical images mosaicked into a 166 m/pixel global data set and topography (665 m/pixel) from MESSENGER's Mercury Dual Imaging System (MDIS) and Mercury Laser Altimeter (MLA) (250 m/pixel). All data products are available from the Planetary Data System (PDS). The data was analysed in ESRI ArcGIS 10.3 environment. The CraterTools extension in ArcMap [9] was used to map the basins and their related crater population. We classified basins as either certain, probable or suggested. We use two different mapping approaches by (1) counting craters on the basin rim excluding all resurfaced areas by the smooth plains, and (2) mapping all craters inside the basin cavity, which provides a lower limit crater density and absolute model age (AMA) for the basins. Most commonly we apply the second approach, because the basins are fully or partially covered by plains in various thicknesses [6]; the degree of basin resurfacing is evidently much more substantial than on the Moon. To derive the CSFD of impact basins we will use the CSFD_Tools from [10], and apply the buffered crater counting technique [7] (first and second mapping approaches) and the buffered non-sparseness correction technique (first mapping approach) as in our previous study on the Moon [8]. We will also consider AMA of the impact basins by applying the CraterStats software [11].

3. Preliminary Results

We identified 80 certain or probable basins on Mercury, twice as much as in the previous study [6]. This increase in number will have substantial implications for the early history of Mercury´s crust. Most of the basins are buried by smooth plains, intercrater plains, or both. In addition, there are complex interactions of basins with lobate scarps and other tectonic landforms. Candidate basins are often surrounded by scarps, rather than obvious intact rims. Thus topography data is extremely useful to find “hidden” basins which were not identified by earlier studies [1, 3, 6].

Some of the more remarkable candidate new basins are candidate landforms stratigraphically beneath Caloris, which have never been described by earlier studies (e.g., Fig. 1). These basins are similar in character to Mendel-Rydberg on the Moon, which is directly superposed by Orientale ejecta, although the additional complication on Mercury is they are also buried by abundant smooth plains.

In summary, our initial results and future work should greatly enhance the understanding of the early Mercury impact record.

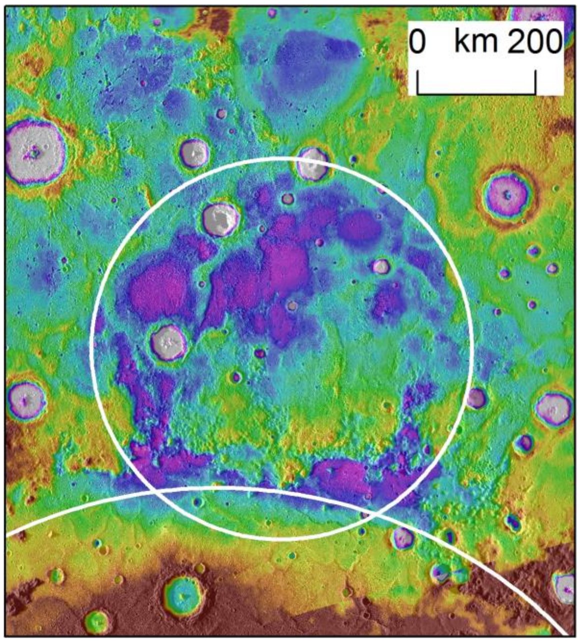

Figure 1: Candidate impact basin beneath Caloris on MLA DEM 250 m/pixel data (165E, 54N).

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