Craters in the Low Latitude Regions of Phobos: Their Distribution, Morphology and Possible Origin

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Phobos, one of the two natural satellites of Mars, has been observed and photographed by several spacecraft. The obtained results have revealed distinct geological features in the lower latitudes of Phobos, such as the blue unit, Stickney crater, and grooves, which are interpreted to be related to crater formation. Furthermore, JAXA's Martian Moons eXploration (MMX) mission, scheduled to launch in 2024, aims to collect and return samples from the low latitude regions of Phobos. To determine the optimal landing site for MMX, it is necessary to investigate the distribution of craters observed in each region using the available image data. The number of craters in and around the Stickney crater was examined in detail using data from the Mars Global Surveyor. A global catalog of craters was created by applying a crater detection algorithm to recent data obtained by the Mars Express.

In this study, we manually counted craters in the lower latitudes (±30 degrees) using high-resolution images and a three-dimensional model to create a precise database of the craters' locations and radii. Additionally, we compared several regions divided into equal latitudinal and longitudinal intervals. To evaluate the randomness of the crater distribution, we employed the nearest-neighbor analysis statistical test. We also estimated impact velocities based on the morphology of the craters. We classified the surface in the lower latitudes of Phobos into four categories: the Mars side (facing Mars), the anti-Mars side (facing away from Mars), the leading side (in the direction of Phobos' orbit), and the trailing side (opposite to Phobos' orbit). We counted craters for each of the eight regions between 30°N and 30°S, spaced every 30° longitude. The images used for crater counting have resolutions ranging from 4.4 to 36.8 m/pixel. The Small Body Mapping Tool was employed to measure the diameters and locations of the craters.

The size-frequency distribution (SFD) of Phobos's craters was determined based on the crater list using Craterstats, and the results are shown in Table 1. The regions where the craters were counted in this study have areas ranging from 67.2 to 89.6 km2, and the maximum and minimum crater diameters are 3.7 km and 0.011 km, respectively. Figure 2 displays the cumulative SFDs of the craters in the four areas.

The powers of the cumulative SFDs are typically higher than the results previously reported for many of the regions, except for the trailing side, which tends to be lower. The power-law index of the trailing side is expected to be statistically low due to the small number of images and low resolution. Craters larger than 200 m were considered relatively reliable data, given the resolution of the images used. It is a challenging task to estimate the ages of planetary surfaces based on crater counting due to the attainment of near saturation levels across all regions. Upon analyzing the cumulative size-frequency distribution (SFD) of craters with the global average of previous studies, derived from a PH9224GT crater catalog, we have observed that the overall crater density is greater in the 100-300 m range of crater diameters. Moreover, our findings reveal that when we concentrate on this particular range, the density of craters on the Mars side, anti-Mars side, trailing side, and leading side is progressively larger. A comparison of the SFD in each area shows that the density of small craters is minimal in the Nearside,

encompassing the blue unit. This observation suggests that there may have been an event that concealed the smaller craters in this region, and that the formation of the blue unit could have played a role in this phenomenon. In our presentation, we will present the distribution of craters in the low latitudes of Phobos and discuss their origins.

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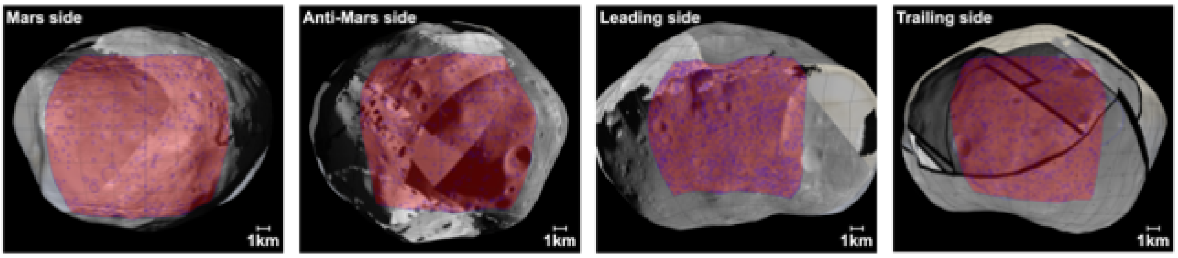

Figure 1. The 4 categories of Phobos (between 30° N and 30° S): Mars side (330° –360° W, 0° –30° W), anti-Mars side (150° –180° W, 180° –210° W), leading side (60° –90° W, 90° –120° W), and trailing side (240° –270° W, 270° –300° W). The circles represent the results of crater counting.

Table 1. The results of the crater counting. The results of the analysis are shown for the 8 regions between 30° N and 30° S every 30° longitude.

Region	Mars side		Anti-Mars side		Leading side		Trailing side	
Longitude	330°–360°W	0°–30°W	150°–180°W	180°–210°W	60°–90°W	90°–120°W	240°–270°W	270°–300°W
Area [km²]	80.8	89.6	88.3	76.6	70.9	67.2	73.7	72.8
Max diameter [km]	2.9	1.2	2.3	1.31	0.81	3.2	3.7	1.97
Min diameter [km]	0.051	0.064	0.046	0.042	0.026	0.027	0.011	0.013
Power law index	2.58	2.61	2.98	2.23	3.04	2.57	1.76	1.68

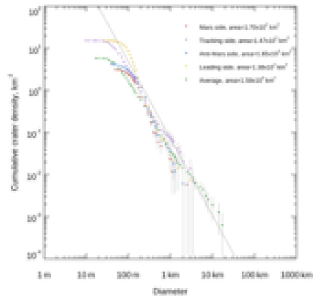

Figure 2. The cumulative crater size-frequency distribution. Each color represents the following areas. Red: Mars side, purple: trailing side, blue: anti-Mars side, yellow: leading side, green: average (PH9224GT).

