

Distribution of Primary Impacts on Phobos and Deimos Based on Numerical Simulations

*Hiroshi Kikuchi¹

1. Gakushuin university

The distribution of craters formed by primary impacts is important for estimating the surface age and geological history of celestial bodies. In particular, distinguishing the effects of secondary impacts is crucial for interpreting crater distributions correctly. For example, on the Moon, ejecta from primary impacts re-impact the surface in radial or concentric patterns, making it possible to differentiate secondary craters (e.g., [1]). However, on irregularly shaped small bodies or in systems where multiple gravitational influences exist, such as the presence of another nearby body, distinguishing secondary craters becomes significantly more challenging.

The surfaces of the Martian moons Phobos and Deimos are considered to be near geometrically saturated, suggesting they are geologically ancient [2]. Due to the complex impact environment involving secondary impacts from their own ejecta, Mars, and potentially other satellites, interpreting the observed crater distributions on these moons is difficult [3,4]. Furthermore, the degree to which primary impactors originate from outside the Martian system remains uncertain.

In this study, we performed numerical simulations to investigate the distribution of primary impacts on Phobos and Deimos. We randomly distributed impactors on a spherical surface located 200,000 km from the moons and simulated their trajectories, considering the gravitational influences of Mars and its moons. The moons were modeled as spheres, and we also varied the Mars-moon distance in the simulations to examine its effects.

The results indicate that as the distance between Mars and Phobos increases, the asymmetry between the leading and trailing hemispheres decreases. Comparisons between Phobos and Deimos showed that Phobos exhibited greater hemispherical asymmetry. Furthermore, when analyzing the distribution between the sub-Mars side and the anti-Mars side, Phobos showed a slightly lower impact frequency on the sub-Mars side, whereas Deimos exhibited almost no difference. For Phobos, when considering relatively large craters in existing crater databases [5] as being primarily formed by primary impacts, we compared the observed asymmetry between the leading and trailing hemispheres with our numerical simulations. The results showed that varying the Mars-Phobos distance did not reproduce the observed level of asymmetry. This suggests that additional mechanisms, contributing to a higher impact flux, may be at play on Phobos, beyond impacts originating from outside the Martian system.

References:

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