Surface slope distributions of Phobos and Deimos: Implications to Surface Materials

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The origin of the Martian moons, Phobos and Deimos, remains unresolved, with two main hypotheses proposed, such as 1) asteroidal bodies originating outside the Mars system were captured by Mars' gravity [e.g. Hunten, 1979] and 2) they formed from ejecta accumulated after impacts with Mars by asteroids or other celestial bodies [e.g. Hyodo et al., 2017]. Understanding the composition of Phobos and Deimos is crucial to constrain their origin, particularly to determine whether they contain material originating from Mars or retain primitive information from asteroids or other sources. Spectral observations of Phobos suggested that it possesses two spectral units: "blue unit" with an overall flat spectrum and "red unit" with a steep spectrum in near-infrared, indicating different compositions for each unit [e.g. Murchie et al., 1991]. Deimos exhibits spectral features comparable to the red unit [e.g. Murchie et al., 1999]. While spectral observations provide important insights, determining the composition based only on spectral features is challenging, highlighting the need for alternative perspectives.
Variations in the angle of repose due to celestial materials have been noted, suggesting that the slope distributions would differ based on material composition. Therefore, this study focuses on the slope distribution of small bodies. The objective of this study is to investigate how the slope distributions differ for blue/red units of Phobos, Deimos, and other small bodies, and discuss their material characteristics.
To determine the slope distribution, gravitational calculations using numerical methods are conducted to estimate the forces acting on the surfaces of small bodies. In addition to the body's own gravity, the combined forces of centrifugal force and tidal forces from the planet for satellites are considered to calculate the overall gravitational force. The slope angle is defined as the angle between the horizontal plane and the plane of interest, and calculations are performed to determine the slope of each surface and calculate its frequency distribution.
First, the slope distributions for both units of Phobos are compared. The results show that the proportion of slopes ranging from 0˚ to 10˚ is higher for the red unit than the blue unit, while the proportion of slopes ranging from 25˚ to 40˚ is higher for the blue unit than the red unit, suggesting the possibility of different materials for each unit. Second, the slope distributions of Deimos and Phobos are compared. It is found that Deimos has a higher proportion of slopes below 10˚ than Phobos, while Phobos has a higher proportion of slopes above 10˚ than Deimos, suggesting the possibility of different materials for both bodies. However, it is important to consider the possibility that differences in the resolution of shape models may have contributed to these results and require further investigation.

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