論 文 の 内 容 の 要 旨

論文題目　Surface evolution on the Martian satellites under the influence of Mars
（衛星・惑星間の相互作用に着目した火星衛星系の表層進化）

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Phobos is an intriguing satellite of Mars. This small satellite, only 22 km in diameter, is very dark with only 0.07 in albedo, and is the closest satellite to a planet in the solar system. The proximity to the planet is significant because the satellite orbits near the Roche limit of Mars, where fragmentation of object is supposed to occur. Understanding the physical process in the vicinity of the Roche limit in detail is necessary not only for unraveling the evolutional history of Martian satellites but also for knowing the growth process of a planetary body.

Around the Roche limit, rings and satellites can coexist. Modern or ancient existence of Martian rings similar to those of Saturn, have been debated for decades. The putative rings may have formed by materials ejected from Mars [*Craddock*, 2011], Martian satellites by impacts [*Soter*, 1971; *Ip and Banaszkiewicz*, 1990; *Hamilton*, 1996], or by the disruption of a small body such as a captured asteroid like a Saturnian ring [*Dones*, 1991; *Charnoz et al.*, 2009]. In addition, Phobos may have broken apart 20-40 Mya to form a ring from the effect of Mars-driven tidal stress [*Black and Mittal*, 2015]. Numerical studies show that Martian satellites, in addition to Phobos and Deimos, may have existed in the past [*Rosenblatt et al.*, 2016]. These studies indicate that the Martian rings may have formed by the disruption of a satellite. However, Martian rings have not been directly observed yet. If such a ring(s) existed in the past, then the linear depressions commonly called grooves ubiquitously existing on the surface of Phobos may be their consequences.

Numerous linear depressions (grooves) are found on Phobos, but not on Deimos. This might be important to understand the origins and surface evolutions of these Martian satellites. Several formation processes of linear depressions on Phobos have been hypothesized and discussed for years. However, none of these hypothesized processes can successfully explain the difference in surface expression between the two satellites, which includes the grooves on Phobos and the relatively smooth surface on Deimos. In this comprehensive investigation, we mapped the linear depressions by using thousands of images of Phobos to plot each lineament on a numerical shape model (known as Gaskell shape model) in order to accurately determine their distribution patterns. We found that all of the identified linear depressions exist on the corresponding planes, and they could be divided into five trend. This result indicates that the linear depressions are not due to collapse of the surface of Phobos. We, instead, propose that these depressions are results of impacts by chains of projectiles; A small body with a rubble-pile structure held together by self-gravity could be pulled apart and stretched into an alignment by tides during the body's close approach to Mars.

Through computer simulations using a N-body numerical code and scaling law, the patterns of pit chains consistent with those observed in the images of Phobos can only be produced when the stretched rubble-pile body orbits about Mars. The deficiency of linear depressions can simply be explained by Deimos's orbit never having intersected Mars's rings, as its distance away from both Mars and the rings may have been too great. Or, it is possible that there were particles beyond the rings, though not accumulated into a ring about Mars, which could have resulted in the formation of a groove or impact craters. But, grooves are not observed on Deimos, and thus, such a case is only likely to have formed impact craters. Consistent with this hypothesized mode of formation of the observed lineaments, intersection of Phobos with ancient Martian rings composed of < 10 m-diameter fragments can also explain their origin.

References

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