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Geological features and surface processes on saturnian small satellites

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Gas giants have numerous small satellites, which are expected to have environments similar to asteroids and comets in terms of such as the tiny gravity, icy surface compositions, and the deficiency in endogenic processes. Therefore, studies of these small satellites can contribute to understand the evolutions of asteroids and comets and can be regarded as an important clue of formations and evolutions of solar system and gas giant systems. After Cassini arrivals at Saturn in 2004, Cassini obtains numerous high-resolution images of Saturnian small satellites. In this presentation, based on our finding and analyses, we focus on the geological features and surface processes of Pan, Daphnis, Atlas, Janus, Epimetheus, Methone, Pallene, Telesto, Calypso, and Helene.

Pan, Daphnis, and Atlas are located at the main ring region, which holds the satellite system with the most inner orbit of the Saturn system. Their shapes are close to a disc-like ellipsoid, which is explained to be formed by the accumulation of main ring particles. Their surfaces show an unusual smoothness without craters or grooves. We newly find the existence of an impact crater on Atlas through our detail investigations. In addition, based on theoretical studies of electrostatic environments, their surfaces have the electrostatic potential enough to levitations of a particle on the surface due to the repulsion forces of electrostatic forces. As a result, we conclude that these satellites may have the resurfacing process due to dust levitation.

Helene is located at the E ring region, whose orbit is known as the leading trojan orbit of Dione. We find that this satellite has a hemispheric dichotomy; its trailing hemisphere has numerous impact craters close to the saturated-condition, while its leading hemisphere is deficient of impact craters. Also, the leading hemisphere of Helene shows numerous gully-like depressions. We develop the shape and gravitational conditions of Helene, where we find that these gully-like depressions strictly follow the local gravitational slopes ranging from 7 to 20 degrees. This indicates that these features are depositional and formed by gravity-induced mass movements. Also, these hemispheric dichotomy can be explained by the accumulations of the E ring materials erupted by the cryovolcanic activity of Enceladus. We find that Telesto, Calypso, Pallene, and Methone, which are also located at the E ring region, are also affected by the E ring, as well as Helene. As a result, based on the total amount and the density of craters on the E ring deposits of satellites, we conclude that the cryovolcanic activity on Enceladus has a short lifetime, possibly only several My.

Janus and Epimetheus are small inner satellites known as the co-orbital satellites. Their surfaces have numerous impact craters with near-saturated conditions, which indicates that these objects are old satellites in Saturn system. Through detailed investigations of high-resolution images, we newly find both satellites consist of the distinct two terrains, such as dark and bright terrains. The dark terrains distribute on the gravitational lowlands and each dark terrain is isolated over all the satellite, which shows the pond-like appearance. The difference between the nature of dark terrains of Janus and Epimetheus cannot be identified in terms of (1) a surface flatness or smoothness, (2) an albedo, which is darker than surrounding bright terrains, (3) an existence as deposits on lower land, and (4) a sharpness of the boundary between darker terrains and surrounding bright terrains. We find that almost all dark terrains on Janus appear to exist at the equatorial region of anti-Saturn side and almost all dark terrains on Epimetheus at the south polar region. As a result, we conclude that these distributions of dark terrains can be explained by the coefficient with the Janus-Epimetheus ring system.

Keywords: Saturn system, small satellite, ring, geological feature