Geological investigation of the blue unit on Phobos

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The surface of the Martian satellite, Phobos, is spectrally divided into two units: red and blue. Understanding their difference may be key to determining the origin and evolution of Phobos, because the blue unit has commonly been interpreted to be composed of original materials of Phobos. Whereas the red unit is distributed nearly globally, the blue unit maps to some relatively small impact craters and the largest crater on Phobos, ~ 9 km-diameter Stickney crater, and its nearby surroundings. Hypotheses to explain its distribution include: (1) emplacement of low-velocity ejecta from the Stickney impact [1], (2) landslide materials extending to the west of Stickney crater [2], and (3) an inner heterogeneous structure of Phobos [e.g., 3; 4]. Regarding (1), Thomas 1998 suggests that low-velocity Stickney ejecta are capable of distributing asymmetrically due to the effects of Phobos' rapid spin, however the emplacement velocity did not be considered. The ejecta may have been emplaced beyond the extent hypothesized. Using high-resolution images, we investigate this with high precision.
We examine the largest region of the blue unit east of Stickney by: changing the NIR/BG color ratio for the western part of HiRISE (High Resolution Imaging Science Experiment) images based on the analysis of [5]. In order to compare these maps, we create a dynamical potential map by dividing the numerical shape model [6] into 1,672,215 small triangular pyramid. From the tidal, centrifugal, and self-gravitational forces [7], we calculate the dynamical potentials at 121,770 points on the surface of Phobos. In addition, we perform numerical simulations in order to examine the relationships between the patterns of Stickney ejecta and regions of blue unit. Considering the rotation of Phobos, as well as the gravity of Phobos and Mars, we map the emplacement where the simulated orbit of particles and the sphere of Phobos intersect and calculate the emplacement velocities based on our simulations. In the calculation of the potentials and the simulations, we change values of the distance between Phobos and Mars from 20,000 km to 9,376 km to account for the changing distance through time. Moreover, we calculate the angle and the direction of the potentials.
As a result, many blue materials exist on the floor of craters and grooves. Comparing the spatial extent of the blue unit in the region east of Stickney crater to the slope map, a greater occurrence of the blue unit is observed on gentle slopes with increasingly less occurrence with greater slope angle. When performing comparative analysis among the maps generated based on varying orbital distances, the extent of the blue unit appears to be consistent with the current orbit. From our simulations, the emplacements of low velocity ejecta of Stickney cover one of blue unit regions east of Stickney.
Our results suggest that blue material easy to move rather than red material. Moreover if the origin of materials composing the blue unit is ejecta of an impact crater of Phobos, the emplacement velocity of the ejecta deposits must be lower than the escape velocity of Phobos. Based on these investigations, we interpret that the Stickney crater is underpinned by the blue unit with its surface being modified into the ubiquitous red unit through space weathering among other processes. Subsequently, the impact event except for Stickney might expose fresh blue materials.
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