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Statistical analyses of lineaments on Phobos: implications to their formational processes and orbital environment

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There are mainly two hypotheses on the origin of the martian satellites, Phobos and Deimos. One is that they are captured, because these spectra are similar to D-type asteroids in the outer main asteroid belt and outer solar system. The other is that they formed in situ from a disk of debris in Mars' orbit, because these are low inclination and near-circular orbits. In the former hypothesis, there is a difficulty accounting for these physical characters. Therefore in situ formational models have been studied in detail. One of the models for the origin of Phobos and Deimos is as follows. Primary many moonlets have formed by accretion of disk materials and orbited Mars. These moonlets fall back towards the martian surface by tidal perturbations, and finally only two moons, Phobos and Deimos, remain in present martian system [1].

Schmedemann et al. [2] estimated 4.3 Ga for the formation age of Phobos and Deimos by crater chronology. In numerical analyses, moonlets with Deimos' mass can accrete near the synchronous orbit. A Phobos' mass moonlet could also be formed in the same disk. This moonlet is however formed closer to Mars. Thus, it collides with Mars because of tidal decay of its orbit. Therefore Phobos' mass moonlet needs to be formed near to synchronous orbit [3]. The ancient distance from Mars is a clue to the origin of the martian satellites.

On the other hand, lineaments on Phobos are the most extensively-existing geological features on the satellite, and thus are documented and discussed for years [4]. From principal component analysis, we confirmed the important character that all the lineaments lie on planes. We suggest that these structures are certainly a result of a series of impacts of aligned fragments.

We simulate several trajectories that arrive at Phobos, changing the number and the size of fragments. We examine that a small body of a collection of smaller fragments held together by self-gravity in form of a rubble-pile is pulled apart and stretched straightly by tides during a close approach to Mars.

Then we test how the linearly-lined fragments change positions relatively by gravitational effect and how patterns leave on Phobos when the fragments arrive at Phobos.

Collectively, the placement of fragments patterns consistent with the observational facts. Furthermore we suppose that fragments form a ring, because lineaments' widths are almost same, and some lineaments appear to be parallel. In this model, we find Phobos needs to be to synchronous orbit when lineaments form.

Reference
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