Crater chronology functions considering Phobos captured age

*内田 雄揮[1,2]、豊川 広晴[2,3]、臼井 寛裕[2]
*Yuki Uchida[1,2], Kosei Toyokawa[2,3], Tomohiro Usui[2]

1. 東京大学、2. 宇宙科学研究所/宇宙航空研究開発機構、3. 総合研究大学院大学
1. The University of Tokyo, 2. Institute of Space and Astronautical Science/ Japan Aerospace Exploration Agency, 3. The Graduate University for Advanced Studies

Two primary hypotheses have been proposed to account for the origin of Phobos: the asteroid capture and the giant impact. The former suggests that an asteroid from the Main Belt was ensnared by Mars' gravitational pull, while the latter proposes that the moons were byproducts of a massive collision with Mars. One of the scientific objectives of the Martian Moons eXploration (MMX) mission is to resolve the origin of the Martian satellites [1]. The study of the celestial trajectory evolution of the solar system can be further improved by information about the timing of Phobos’ capture in the Martian system, because Phobos is considered to be a D-type asteroid; D-type asteroids are thought to be related to the origin of life because of their high organic matter content, and constraints on the Phobos’ captured age has a possibility to provide the description of the relationship between the origin of life and asteroids. This study aims to make theoretical predictions based on the crater chronology, and to provide useful information for differentiating candidate landing sites (i.e., sampling sites) that yield accurate constraints on the Phobos’ capture age by the returned samples.
The crater chronology functions that express the relationship between the crater number density N and the surface age for each captured age has been investigated on Phobos in light of both the recently captured scenario and the giant impact scenario in the previous study [2]. However, the previous study did not consider the captured timing. Then we made theoretical predictions based on the crater chronology assuming multiple captured ages ranging from 4.5 Ga to 0 Ga using both the crater formation rates in the main belt asteroid region and the Mars orbit region [2]. The crater chronology functions obtained through our study vary significantly reflecting the captured timings. It was found that there is a possibility to make a constraint on the captured age if MMX return samples from a location of about $N(D>1km)$ ˜ 10^{-2}-10^{-1} km^{-2}.
In MMX mission, the surface age of the landing site will be obtained by measuring the shock ages of the Phobos samples independently of the crater chronology [3]. Therefore it is of utmost importance to accurately pinpoint locations that have appropriate crater number density beforehand with MMX mission to constrain the captured age. We also tested the crater size frequency distribution inside of the Stickney crater for a candidate MMX landing site and found an area of $N(D>1km)$ ˜ 10^{-2}-10^{-1} km^{-2}. Our results indicate that there are sites that can lead to a constraint on the captured age vicinity of the Stickney crater.

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