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Granular convection and its application to asteroidal resurfacing timescale

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A model for the asteroid resurfacing resulting from regolith convection is built to estimate its timescale. The regolith convection by impact-induced global seismic shaking could be a possible reason for regolith migration and resultant segregated terrain which were found on the asteroids Itokawa [1]. Some recent studies [2, 3] experimentally investigated the convective velocity of the vibrated granular bed to discuss the feasibility of regolith convection under the microgravity condition such as small asteroids. These studies found that the granular convective velocity is almost proportional to the gravitational acceleration [2, 3]. Namely, the granular (regolith) convective velocity would be very low under the microgravity condition. Therefore, the timescale of resurfacing by regolith convection would become very long. In order to examine the feasibility of the resurfacing by regolith convection on asteroids, its timescale have to be compared with the surface age or the lifetime of asteroids. In this study, we aim at developing a model of asteroid resurfacing process induced by regolith convection. The model allows us to estimate the resurfacing timescale for various-sized asteroids covered with regolith.

In the model, regolith convection is driven by the impact-induced global seismic shaking. The model consists of three phases,

(i) Impact phase: An impactor intermittently collides with a target asteroid [4],

(ii) Vibration phase: The collision results in a global seismic shaking [5],

(iii) Convection phase: The global seismic shaking induces the regolith convection on the asteroid [3].

For the feasibility assessment of the resurfacing process driven by regolith convection, we estimate the regolith-convection-based resurfacing timescale T as a function of the size of a target asteroid D_a.

According to the estimated result, the resurfacing time scale is 40 Myr for the Itokawa-sized asteroid, and this value is shorter than the mean collisional lifetime of Itokawa (about 170 Myr [4]). We find that $T(D_\mathrm{a})$ is shorter than the mean collisional lifetime as long as the target asteroid is small ($D_\mathrm{a} < 10$ km). This means that the regolith convection is a possible mechanism for the asteroid resurfacing process. However, the timescale depends on various uncertain parameters such as seismic efficiency and convective roll size. To clarify the parameter dependences, we develop an approximated scaling form for the resurfacing timescale.

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