CRATERING EFFICIENCY ON AN ASTEROID SURFACE COVERED WITH A BLOCK LAYER.

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Introduction: Recent detailed geochemical analyses of returned Itokawa sample have yielded important age esimations. For example, the cosmic ray exposure (CRE) age of the particles from Itokawa are less than 10 Myr [3,4], and Ar^{40}/Ar^{39} age is reported as 1.26±0.24 Ga [5]. The geologic meaning of these radioisotope ages, however, is not fully understood; their links to specific geologic events on Itokawa and its parent body have not been established yet. One of the obstacles against such geologic interpretation of these radiometric ages is the great ambiguity in the resurfacing processes. More specifically, crater retention age has been estimated to be 75 Myr - 1 Gyr based on strength scaling [2]. This large uncertainty in surface age estimation comes from that in crater size scaling. Furthermore, this uncertainty could be underestimated because cratering on rubble piles, such as Itokawa may not be controlled by target strength.

Accurate understanding of radiometric age estimates would require more accurate crater size scaling on rubble-pile structures with possible mechanical stratification. Although crater experiments on uniformly coarse-grained targets have been conducted [6, 7], Itokawa may have a boulder-rich layer superimposed on a finer regolith-rich substrate [1]. Such structure may also be formed via so-called Brazilian-nuts effect. In this study, we investigate the crater scaling on such layered structures.

Experiments: Impacts of cm-size bodies at the mean impact velocity (~5 km/s) in the asteroid main belt, meter-sized boulders on asteroid surfaces can be easily disrupted. To reproduce this disruption at low velocities (<200 m/s) in a laboratory, we used weakly sintered glass beads blocks (8 - 15 mm) as boulder simulants. We also used 200 µm glass beads as regolith simulant. Three types of targets were used: (1) a 20-mm-thick block layer on a regolith substrate, (2) a 40-mm-thick block layer on a regolith substrate, and (3) a uniform regolith layer. Polycarbonate projectiles 10 mm in diameter were launched at ~70 - 190 m/s.

Result & Discussion: For low impact energies, crater sizes of targets 1 and 2 are smaller by ~20 - 40% than target 3 (gravity scaling), but still much larger than the strength scaling for unfractured targets of sintered glass beads. When impact energy becomes large enough for projectiles to penetrate through the top block layer, crater sizes approach the gravity scaling quickly.

Strength crater scaling rules were used for the estimation of Itokawa surface age by [2].Our experimental results, however, indicate that the crater scaling on coarse-grain targets is rather close to the gravity scaling than the strength scaling. This result is rather consistent with a prediction based on impact experiments with much large impact energy on uniformly coarse-grained targets [7]. Then, the crater retention age of Itokawa would be estimated to be <10 Myr. This age is comparable to CRE age and much shorter than the Ar^{40}/Ar^{39} age (~1 Gy) [5]. This suggests the CRE age may correspond to the Itokawa resurfacing age and that Ar^{40}/Ar^{39} age may correspond to a much older event: a catastrophic impact event on Itokawa's parent body [5].

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