

Experimental Study on the Relationship between Surface distributions and Vertical Structures of Rock Particles on Small bodies.

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Small celestial bodies are covered by numerous rock particles. The distributions of rock particles on small bodies differ significantly from one body to another, reflecting the formation and evolution process of the body [1], and thus needs to be studied in detail. However, the information obtained by exploration is limited, and the distributions of rock particles are studied mostly by analyzing surface images, especially measuring cumulative size distributions (CSFD) of particles [2, 3, 4]. In general, the CSFD of small bodies can be fit by power-law, and the values of power-law index are compared between celestial bodies and different regions on the bodies. However, it is not clear to what extent the power-law indexes contain essential information. In fact, in order to understand the distributions of rock particles, it is necessary to focus not only on the surface but also on the subsurface. For example, layer structure and macroporosity of subsurface is fundamental for investigating the internal structure of small bodies¹. However, the internal structures of small bodies have never been observed, and can only be inferred from gravity and grain density [5, 6]. Therefore, research has been conducted to infer the internal structures of celestial bodies from the results of image analyses [7, 8]. Such studies are based on the assumption that the particle size distributions obtained from surface images represent the interior, but this assumption has never been verified. Therefore, this study aims to verify the extent to which the information obtained from surface images of small bodies reflects the essential information including that of subsurface. Although such study can be performed by numerical simulation assuming spherical particles [9], reflecting the effects of the complex shapes of the rock particles of small bodies is extremely difficult. On the other hand, our approach is to conduct an experiment in a laboratory, where we use rock material made from fractured hornfels which are blended to have the power-law index of -3. When the rock material was laid out on a flat surface, the slopes of CSFD obtained from surface images were less steep than the actual value. In addition, when the material was placed in an acrylic container with an inner diameter of 140mm, the slopes of CSFD obtained from surface images got even less steep than when it was laid out on a flat surface. These results suggest that slope of the CSFD obtained from the images of the surfaces of the small bodies is less steep than the actual slope of the CSFD including the interior. Therefore, constraining the physical properties of the interior only from the surface images of small bodies is revealed to be challenging. Moreover, the material was vibrated in order to observe the effects of surface modifications. The result showed that the slope of the CSFD gradually got less steep. This suggests that the comparisons of the CSFD are important when we discuss surface modification processes of small bodies. Furthermore, the internal structure is visualized by micro-focus X-ray CT to understand how the CSFD on the surface relates to the subsurface structure. From the broad view and high contrast 3D images obtained, the values of macroporosity of the horizontal cross-sections are calculated, and we suggest that the macroporosity falls between 30% and 40%. These findings can be applied to image analyses and simulations to advance discussions on the geology of small bodies.

References

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