Physical Properties of Constituent Material of the Regolith of Ryugu

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The "regolith" covered with surface of moons and planets are nominally thought to be consisted of fine grained materials. However, the surface of Ryugu explored by Hayabusa2 mission seemed to be fully different from that of our understanding. Despite of low thermal inertia inferred from ground observation, the surface was dominantly covered with rocks as large as several meters and larger. It is of great interest to investigate physical mechanism why the Ryugu is top shape [1], and how the large crater of 10m in diameter could be generated by the Small Carry on Impactor (SCI) experiment [2]. Moreover, we found no obvious regolith hopping after the experiment [3]. In order to understanding these remote sensing observations, physical properties of the constituent material of surface must be essential information.

The sample of Ryugu was successfully collected and returned to Earth on 6th Dec. 2020. Fortunately, there are some grains of several to ten millimeters size which enabled us to measure various physical properties. The physical properties which involve four categories as mechanical, thermal, electrical, and magnetic, could give basic parameters of collisional, thermal and others related to the origin and evolution of the body, and they also give us essential clues to understanding of results from remote sensing observations.

The sample we measured intensively was one of the largest samples collected at the second touchdown operation. From this sample, two sliced disk-like shape pieces both of which had about 9-10mm^2 and the thickness of 0.75 and 0.9mm were processed for the measurement of physical properties. As the initial sample analysis activity, we measured sixteen physical properties in total (six for mechanical, two for thermal, two for electrical and five for magnetic properties) successfully [4].

As for the mechanical properties, we measured elastic (longitudinal and shear) velocity, compressive hardness, bending strength, thermal expansivity and cohesive force. They are almost similar values of CI or CM type meteorites. From these properties, we simply could not explain any results deduced from remote sensing and SCI experiment. For example, the cohesive force was 0.17 μN. In order to generate 10m crater by the SCI experiment, large cohesion strength as high as 125-300 Pa is required, which bay be difficult to realize under the cohesive force between large boulders [5].

Heat capacity and thermal diffusivity were measured as the thermal properties, both of their values showed similar values of CM chondrite. From remote sensing observation, global average of thermal inertia is 200-300 (J m^{-2} $s^{-0.5}$ K^{-1}) [6], whereas three or four times lager values as 800-900 (J m^{-2} $s^{-0.5}$ K^{-1}) derived from direct sample measurement. The difference between thermal characteristics of Ryugu observed by the
spacecraft and measured from the returned sample implies that the contribution of smaller grains or fluffy structure on the surface. It is also possible that the small samples collected by the spacecraft may have different thermal properties from boulders on the surface.

In the presentation, we introduce other properties measured by the initial analysis and discuss the characteristics of surface material of Ryugu from the physical aspect.

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