Experimental study on compression property of regolith analogues

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Porosity structure inside a planetary body and of surface regolith plays important role in collisional and thermal evolution of the body. The porosity structure is changed by presence of rocks, seismic shaking, thermal evolution, and self-gravity in particular. Porosity structure caused by soil pressure due to self-gravity gives an initial, most-possible porous structure of the body consisting of granular material. Therefore, understanding compression property of granular material and obtaining general formula for the compression property of granular material in various environments is required to estimate the porosity structure of planetary bodies.

We conducted compression experiments of various kinds of samples. Each sample had different composition and size distribution. Main compositions of the samples were Al_2O_3 and SiO_2 and the particle size is smaller than 100 μm. We sieved these samples into cylindrical container and the top part of the bed over the height of the container was leveled off. The initial porosity of the granular bed was different for different samples and it was in the range of 0.54-0.86. Then we compressed the sample by compressive testing machine. The applied pressure was ranged from 10^4 to 2×10^6 Pa. It was shown that the slope of compression curve becomes shallower as the frictional force between particles increases. The samples with wider size distribution were compressed easier (Omura et al., ISTS, 2015).

The soil pressure is lower than 10^4 near the surface of small bodies or in the bodies with diameter less than ~20 km. Therefore, we conducted new compression experiments. We expanded the pressure range to lower than 10^2 Pa and we found that compaction process of granular bed is divided into following three regimes: (1) Pressure is lower than the strength of granular bed accordingly the granular bed isn't compacted, (2) Granular bed is compacted but the decrease in porosity is gradual, and (3) The porosity decline-rate becomes larger than the regime 2. For example, in case of silica sand of 18 μm median diameter, the threshold pressure between regime 1 and regime 2 was ~50 Pa and that between 2 and 3 was ~200 Pa.