Experimental Study on Compaction Property of Constituent Material of Primitive Body

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The compaction property of the constituent material of the primitive body affects the porosity structure of the body because which determines the results of compaction due to self-gravity and impact pressure. The internal structure of the body is an important property that reflects their evolutional history and affects their physical and thermal evolution. It is difficult to observe the internal structure directly, however, internal porosity structure due to self-gravity, which is the most porous structure of the body, can be estimated when the compaction property of the constituent material is given.

The constituent material of the primitive meteorite parent body is a mixture of the matrix, which consists of dust particles, and other relatively coarse particles such as chondrule. The compaction property of the mixture depends on the volume fraction of each component and their particle size; they vary depending on the chondrite class *(Weisberg et al., 2006)*.

We investigated the relationship between the compaction property of the dust layer and the characteristics of constituent particles from laboratory experimental results of dust samples (*Omura and Nakamura, 2018*). Next, we investigated the effect of particle size of dust and the mixing ratio of components on compaction properties of meteorite analogs. Finally, we calculated the porosity structure of primitive meteorite parent body due to self-gravity using experimental results.

We made samples with dust or mixtures of dust and solid beads. We used various particles with the diameter of the order of 10^0-10^1 micrometers as dust. In cases of mixture samples, we only used two kinds of dust with a median particle diameter of 1.5 μm and 4.8 μm. We also used 4.8 μm particles containing 0.4 wt% of organic particles as dust. The diameter of the beads was 1 mm. These particle sizes are similar to that of the matrix and chondrule of Allende *(Toriumi, 1989; Forman et al., 2016; Weisberg et al., 2006)*. We modified the volume fraction of dust from about 0.2 to 1. We sieved or poured the sample into a cylindrical container and compacted the sample using a piston fixed to a compressive testing machine installed in Kobe University. The loading rate was set at 10 μm/s. The applied uniaxial pressure was up to $\sim 5 \times 10^6$ Pa.

We approximated the obtained compaction curves with a modified polytropic relationship, $P=K' f^{(n+1/n)}$, where P is the applied pressure, K' is a constant, f is the filling factor and n is the polytropic index. In cases of dust only layer, values of K' and n were mainly determined by the median particle diameter of dust irrespective to their composition and particle shape. In a case of dust layer consists of lumps, the size of lumps rather than individual particles might determine the compaction property of the layer (*Omura and Nakamura, 2018*). In cases of the mixture of the dust and beads, their compaction behavior was dominated by dust in cases of the volume fraction of dust larger than ~0.5. Organic particles did not affect compaction behavior.

The approximated compaction curves were applied to the Lane-Emden equation to estimate the porosity structures of primitive meteorite parent bodies due to self-gravity. We compared them with the bulk porosity of asteroids. It was suggested that the volume fraction of the matrix is higher than ~0.4 to achieve the porosity of C type asteroids and typical matrix size of C type asteroids is smaller than 4.8 μm.