**EXPERIMENTAL STUDY ON THE PRIMORDIAL POROUS STRUCTURE OF CHONDRITE PARENT BODIES DUE TO SELF-GRAVITY.** T. Omura[1] and A. M. Nakamura[2], [1] Department of Planetology, Graduate School of Science, Kobe University (1-1 Rokkodai-cho, Nada-ku, Kobe, Hyogo, 657-8501, Japan t.omura253@gmail.com), [2] Department of Planetology, Graduate School of Science, Kobe University.

**Introduction:** The bulk porosity of asteroids, which are considered as chondrite parent bodies, have been estimated by the bulk density of the bodies and the assumed grain density based on that of chondrites and shown that below 300 km in diameter, C type asteroids tend to have higher porosity than S type asteroids [1,2]. Chondrites are also porous: Carbonaceous chondrites have higher porosity than ordinary chondrites [1].

The bulk porosity of a rubble-pile body is sum of macroporosity (the fraction of void space between rubble) and microporosity (the fraction of void space in rubble), and may be ~0.5-0.6 as described in the following. The macroporosity of a rubble-pile body is estimated to ~0.4-0.5 based on experimental results of relatively coarse (much larger than micrometer) particles. For instance, the porosity of randomly aggregated fragments produced by an impact experiment was ~0.5 [3]. The granular layer consists of particles larger than submillimeter typically has porosity of ~0.4 [e.g., 4]. The microporosity of constituent rocks of rubble-pile bodies is maybe ~0.1 and ~0.2 for S type and C type asteroids, respectively, based on the porosity of ordinary and carbonaceous chondrites [1]. Accordingly, the porosity of a rubble-pile body may be ~0.5-0.6. The estimated bulk porosity is consistent with the bulk porosities of explored rubble-pile asteroids, Itokawa (~0.5[2]) and Ryugu (~0.6), which are derived from the density of the asteroids [5,6] if the grain density of LL and CM chondrite [1] are respectively assumed. However, the microporosity of constituent rocks of a rubble-pile can be higher than 0.2: Only less porous and stronger pieces may have survived the atmospheric entry [1]. Indeed, the porosity of Tagish Lake meteorite has been reported to ~0.3 [7].

In cases of granular layers consisting of micrometer-sized particles, a porosity higher than ~0.5 can be achieved [8]. Therefore primordial (not rubble-pile) chondrite parent bodies possibly have higher porosity than rubble-pile bodies, because they have fine matrix as their components. The porosity structure of a chondrite parent body is determined by self-gravity, compaction due to impact, impact-induced vibration, and thermal and water alterations, etc. In particular, the porosity structure due only to self-gravity is the initial, most porous one, and can be estimated, once the compaction behavior of the constituent material is approximated by a power-law function [8]. The compaction behavior of the constituent materials of a chondrite parent body should depend on the volume fraction and particle size which vary with chondrite type [9].

In this study, we investigated how volume fraction and size of matrix grains affect the primordial porous structure of chondrite parent body. We conducted compaction experiments using dust-beads mixtures as analogs of chondrite components. Then we calculated internal porosity structure and bulk porosity of chondrite parent bodies due to self-gravity using our experimental results and compared them with the bulk porosity of asteroids.

**Experiments:** We used two kinds of dust, i.e., silica powder and fly ash, as analogs of matrix grains and glass beads as chodrule analog. The silica powder and the fly ash have volume-based median diameter of 1.5 μm and 4.8 μm, respectively. The glass bead has diameter of 1 mm. Their sizes are similar to those of Allende components [9,10,11]. We prepared mixtures of one of the dust and the glass beads with different mixing ratio. We conducted compaction experiments of the mixtures in a similar way with our previous study [8]. We poured the mixture into a cylindrical container and compacted it using a piston fixed to a compressive testing machine. The applied uniaxial pressure was up to about $5\times10^6$ Pa. Loading rate was 10 μm/s.

**Results:** Figure 1 shows results of experiments. Results of the mixture of 1.5 μm dust are shown in color and that of 4.8μm dust are shown in black. Filling factor increases with applied pressure. The mixtures with lower dust volume fraction have larger filling factor under the same applied pressure. The mixtures of the smaller dust grains have smaller filling factor, and easier to be compacted. This is because the dust layer composed of smaller particles had lower filling factor and was easier to be compacted [8]: Dotted curves show the results of dust only layers.

**Calculation of bulk porosity of primordial chondrite parent bodies:** We calculated the porosity structure and bulk porosity of primordial chondrite parent bodies based on the approximated compaction behavior of our samples. When we assume the hydrostatic equilibrium, continuity of interior in the body, and that the compaction behavior of constituent materials of the body can be approximated by a polytropic relationship, the internal porosity structure of the body can be calculated using Lane-Emden equation [8]. Curves and symbols in Figure 2 indicate the calculation

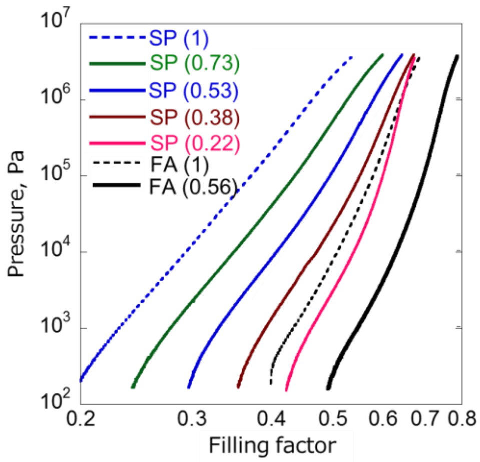


**Figure 1.** Results of experiments. Samples were mixture of fly ash (FA) with median diameter of 4.8 µm and glass beads with diameter of 1 mm (color curves) and silica powder (SP) with median diameter of 1.5 µm and glass beads with diameter of 1 mm (black curves). Numbers in parenthesis indicate volume fraction of dust.

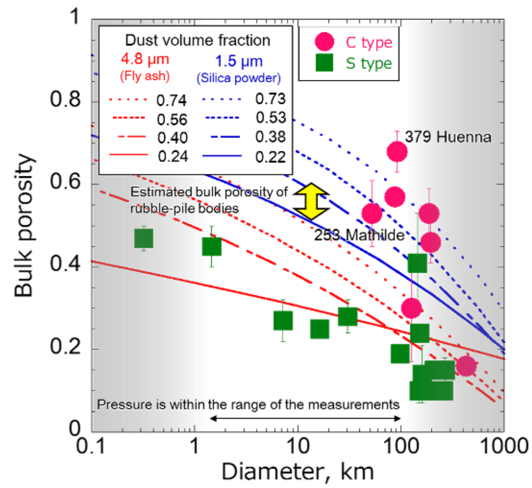


**Figure 2.** Calculation result and bulk porosity of asteroids [2]. Bright area indicate that the pressure at the center of the body is within the range of the measurements in this study. The bulk porosity of Huenna was obtained by the bulk density of Huenna [13] and grain density of CM chondrite [1]. The mass of Huenna, which is a primary of a binary system, was determined by the total mass of the system and the size ratio of the primary and the satellite estimated by the flux with an assumption of that they have the same albedo. The size of the primary was estimated from IRAS data. The bulk porosity of Mathilde was estimated by the data obtained by NEAR's flyby [14] and grain density of CM chondrite [1].

results and the bulk porosities of asteroids [2], respectively. The porosity of a body tends to decrease with decreasing dust volume fraction and increasing dust particle size. The porosity of most of C type asteroids is only achieved in cases of 1.5 µm dust with the dust volume fraction larger than ~0.4. This result suggests that the volume fraction of the matrix should be higher than 0.4 for the bodies with the porosity of C type asteroids. This may be a reason for the fact that most of asteroids with high porosity are C type. It is also suggested that the typical matrix size of C type asteroids may be smaller than 4.8 µm.

In cases of the asteroids with the porosity higher than ~0.5-0.6, both the primitive structure due to self-gravity and rubble-pile structure can be considered. For instance, 379 Huenna (porosity ~0.7 [2]) and 253 Mathilde (porosity ~0.5 [2]). However, Mathilde has multiple large craters and it was suggested that they are formed by compaction [12]. Therefore initially Mathilde may have larger porosity than the present value.

The constituent materials of carbonaceous chondrite parent bodies should have included ice and organic matter, and should have affected the compaction behavior of constituent materials. Further studies about the effect of the volume fraction and the spatial distribution of ice and organic particles on the compaction behavior are needed.

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