FRAGMENT VELOCITY DISTRIBUTION OF CORE-MANTLE BODIES IN COLLISIONAL DISRUPTION. C. Okamoto[1], M. Arakawa[1], [1]Graduate School of Environmental Studies, Nagoya University, Nagoya 464-8601, Japan (chisato@eps.nagoya-u.ac.jp)

Introduction: According to the study on the planetary evolution process, planetesimals are supposed to be porous bodies with homogenous internal structure. In their growth process, the thermal evolution of the planetesimal interiors could cause pressure sintering, melting and gravity differentiation of the constituent materials. As a result, there could be a lot of growing bodies with heterogeneous internal structure: usually they might have a layered structure such as a silicate core-porous silicate mantle or a metal core -rock mantle. So, we should consider a collisional phenomenon not only for homogenous bodies but also for layered (core-mantle) bodies in order to study the planetary accretion process.

Parent bodies of various meteorites are considered to have been formed by a collisional process of such layered bodies. In the collisional process of parent bodies, many fragments were formed. We think that the fragments having the velocity below an escape velocity of the parent body were reaccumulated, then a body having rubble pile structure and regolith surface was formed. Therefore, the velocity distributions of fragments are very important to consider the origin of meteorite parent bodies.

A lot of experiments and numerical simulations on the impact disruption have been performed by previous studies of homogeneous materials such as silicate and ice [e.g., 1, 2, 3, 4], and several data was acquired for the antipodal velocity and velocity distribution. But we do not have any data on the collisional disruption of core-mantle bodies. So, we investigate the fragment velocities of core-mantle targets in order to clarify the difference of reaccumulation condition between homogenous targets and core-mantle targets.

Experimental: (1) *Collisional disruption of core-mantle bodies.* Glass core-gypsum mantle samples were prepared for the spherical target. The core, which was a glass bead, was surrounded by a gypsum layer. The important parameters to characterize the core-mantle body are a mantle thickness (t_m) and a ratio of the glass core mass to the total sample mass, which is hereinafter called as Core Mass Ratio (CMR). The CMR of our samples was changed from 0 to 1 by varing a sample mass (1-35g), a glass bead diameter (3-16.7mm) and a gypsum mantle thickness (0-12.5mm). The density of the glass bead was about 2.5g/cm^3, and the density of the gypsum layer was about 1g/cm^3, which meant that this layer had a porosity of about 50%.

We used a two-stage light gas gun set in Nagoya University for impact experiments. The projectiles were made of nylon, and the masses and lengths (d_p) were 4-7mg and 2-3mm, respectively. The impact velocities (V_i) ranged from 1.5 to 5km/s, then energy densities of impact experiments were 1×10^3-4×10^4J/kg. The collisional disruption was observed by an image-converter camera which was able to take successive images of 15 frames up to 5×10^5 F. P. S., and a high speed digital video camera was also used to observe the collisional phenomena at 4×10^3-2×10^4 F. P. S.

(2) *Measurement of particle velocity attenuation in gypsum and glass.* We prepared gypsum plates with the thickness from 1.9mm to 10mm. Moreover, we prepared two-layered plate samples (glass plates sandwiched between gypsum plates). The glass plate thickness was 2mm and the gypsum plate thickness was from 1.5 to 5.5mm. The impact velocities (V_i) ranged from 1.5 to 4km/s. The antipodal velocity, by which we can know the attenuation of particle velocity in gypsum, was measured by an image-converter camera and a high speed digital video camera.

Results: (1) *Core-mantle bodies.* We studied the relationship between the largest fragment mass and the energy density to determine the impact strength of core-mantle bodies. We compared previous results of basalt, glass and gypsum targets [5, 6, 7] with our results of core-mantle targets. Our glass ball result (CMR=1) shows a good agreement with previous basalt data [5], and our gypsum results also show a good agreement with previous gypsum data [7]. Our core-mantle data having various gypsum mantle thickness and various CMR spread between the glass ball data and the gypsum data. Therefore, we speculate that the behavior of core-mantle targets in collisional disruptions strongly depends on the key parameters, the mantle thickness and the CMR.

Shock wave might extremely attenuate in the gypsum mantle due to the high porosity (~50%). So, we especially noted the gypsum thickness of core-mantle targets, and examined how the thickness of gypsum mantle affected the disruption of glass core at various energy densities. We studied the relationship between the degree of disruption of the glass core and the gypsum thickness. As a result, when the glass core was disrupted, the value of t_m/d_p (the gypsum thickness normalized by the projectile length) was noticed to be always below 1.6. This suggests that the degree of disruption of the glass core was strongly dependent on the gypsum thickness. Furthermore, our result showed that the core disruption was also dependent on the energy density.

We analyzed the fragment velocity distributions of core-mantle bodies having various CMR. Fig. 1 shows the fragment velocity (V_e) at various points from the impact site. The impact point and the antipodal point correspond to the positions of 0 and 90 degree, respectively. As the CMR increases, it is obvious that the velocity distribution of the core-mantle body shows the maximum value around the antipodal point.

(2) *Particle velocity attenuation in gypsum and glass plates.* As a result of our impact experiments for gypsum plates, we found that there was a critical thickness of t_m/d_p = 1.6 at which the attenuation of the antipodal velocity drastically changed. It was also found that the antipodal velocity rapidly attenuated in proportion to the forth power of the gypsum thickness at the thickness larger than t_m/d_p = 1.6. This may suggest that the possibility such as the shock pressure greatly attenuated before the shock wave reached the glass core.

The antipodal velocity of a two-layered plate was several times larger than that of a gypsum plate at the same thickness. According to this result, we propose a shock wave attenuation model for a two-layered target that the shock pressure hardly attenuates in the glass region and rapidly attenuates in the gypsum region.

Discussion: The fragment velocity distributions of core-mantle bodies having the higher CMR (>0.5) showed the maximum value around the antipodal point (Fig. 1). The fragment velocity distribution of the homogenous body usually shows the minimum value around the antipodal point. Therefore, the difference of the velocity distribution among them was obviously caused by the glass core.

In order to simulate this feature, we calculated the fragment velocity at various positions from the impact point by using the model proposed for the shock pressure attenuation in the two-layered target. We consider 4 artificial glass core-gypsum mantle bodies, which diameters are 60mm and the gypsum mantle thickness are from 2.5 to 20mm. The calculated results are shown in Fig. 2. The impact point and the antipodal point correspond to the positions of 90 and 0 degree, respectively. Surprisingly, the results show a good agreement with the velocity distribution of core-mantle bodies obtained from the impact experiments. This suggests that the proposed model could be applicable to the two-layered target.

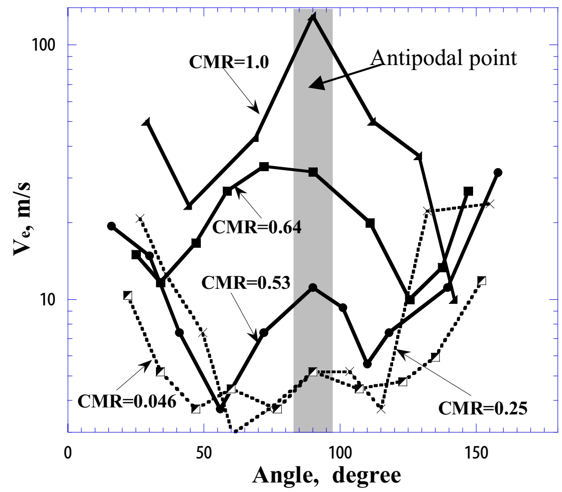

Fig. 1 Fragment velocity distributions of core-mantle bodies in impact experiments. The dotted lines show core-mantle targets, which cores were not disrupted. The straight lines show core-mantle targets, which cores were disrupted. When the CMR is lager than 0.5, the fragment velocity distribution has the maximum value around the antipodal point.

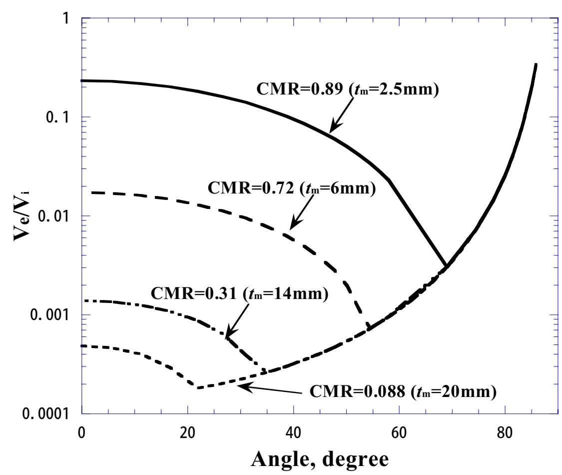

Fig. 2 Calculated results of fragment velocities at various positions from impact point for 4 artificial core-mantle bodies. As the CMR increases, the fragment velocity increases. When the shock wave passes through gypsum region with the longest distance in the core-mantle bodies, the fragment velocity has the minimum value.

References: [1] Arakawa M. (1999) *Icarus 142*, 34-45. [2]Nakamura A. and Fujiwara A. (1991) *Icarus 92*, 132-146. [3]Nakamura A. et al. (1992) *Icarus 100*, 127-135. [4] Asphaug E. and Melosh H.J. (1993) *Icarus 101*, 144-164. [5] Fujiwara A. and Tsukamoto A. (1980) *Icarus 44*, 142-153. [6]Gault D.E. and Wedekind J.A. (1969) *J. Geophys. Res. 74*, 6780-6794. [7]Kawakami S. et al. (1991) *Astron. Astrophys. 241*, 233-242.