Toward laboratory collisional disruption experiments of pieces fragments of Tagish Lake meteorite

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The Tagish lake meteorite is different from other carbonaceous chondrites in the reflectance spectra and is similar to those of D-type or T-type asteroids [1]. The semi-major axis of most D-type asteroids is larger than 3 AU. They locate farther from the Sun than S-type asteroids and C-type asteroids, the parent bodies of ordinary and other carbonaceous chondrites. If the asteroids formed in the current heliocentric distance, D-type asteroids may have a higher abundance of volatile materials and pre-solar grains than C-type asteroids, and less influence from thermal metamorphism, and therefore are important for understanding the origin of the volatile materials that have been brought to Earth[2].

It is desirable to use the Tagish lake meteorite to understand collisional disruption and evolution of D-type asteroids. However, the total mass of the recovered Tagish lake meteorite in good condition and with little contamination was only 850 g [3]. In this study, we performed laboratory collisional disruption experiments of tiny pieces of Tagish lake simulant UTPS-TB[4] with the aim of conducting impact disruption experiments using tiny pieces of Tagish lake meteorite in the future.

The bulk density of UTPS-TB is 1.43±0.04 g/cm^3. Assuming that the composition of UTPS-TB is the same as that of Tagish Lake meteorite, the porosity is 46 %. Tensile strength and compressive strength were measured for a cylinder with a diameter of 20 mm and a height of 6 -21 mm at a loading rate of 0.001 mm/s. The results were 0.222 ±0.087 MPa and 1.11 ±0.31 MPa, respectively.

Using a gas-gun at Kobe University, we performed collisional disruption experiments with a projectile of 1mm glass sphere of impact velocity 150~160 m/s. Mass of the tiny piece used as a target was 0.025-0.180 g. The target was placed in a fragment collection box to prevent the fragments from scattering. The box would cause secondary disruption of fragments, so a high speed camera was installed to determine the mass of the largest fragment from the image. We measure the area of the largest fragment by ImageJ. The equivalent circle diameter asuuming a sphere, was 0.78-2.63 mm. The mass of the largest fragment was obtained by calculating the volume. We call these tiny targets "Small" (M_t< 0.2 g) and the data was compared with the high velocity impact experiments using a 3.2 mm projectile ("Large": M_t > 50 g).

The mass of the target and the largest fragment are expressed as M_t and m_L respectively, and the relationship between the energy density Q (defined by the kinetic energy of a projectile per unit mass of the system) and the largest fragment mass fraction (m_L/M_t) was summarized. The Q* of "Small" is 200 J/kg, which is less than the Q* =1000 J/kg required for the "Large" target. The tendency for Q* at low velocity to be smaller than Q* for high velocity is consistent with gypsum with 67 % porosity (density 0.77 g/cm^3)[5]. "Small" was also compared with the result of low-velocity experiments with 1 mm projectiles against targets of this gypsum[5] and pyrophyllite[6] (density is 2.62 g/cm^3). The disruption threshold was similar to that of gypsum. "Large" was also found to be as weak as the high velocity Large targets of gypsum[5].

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References

[1] Hiroi, T. et al. (2001), Science 293, 2234 -2236.

[2] Fujiya, W. (2016), Planetary People 25, 90-93.

[3] Brown, P.G. et al. (2000), Science 290, 320.

[4] Miyamoto, H. et al. (2018), LPSC 49th, Abstract #1882.

[5] Nakamura, A. et al. (2015), Planet Space Sci. 107, 45-52.

[6] Nagaoka, H. et al. (2014), Meteorit. & Planet. Sci. 49, 69-79.

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