Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS21-02 Room:201A Time:May 21 15:45-16:00

The effects of multiple impacts on the impact strength of ice targets

HAYAMA, Ryo[1*], ARAKAWA, Masahiko[1]

[1]Graduate School of Science, Kobe University

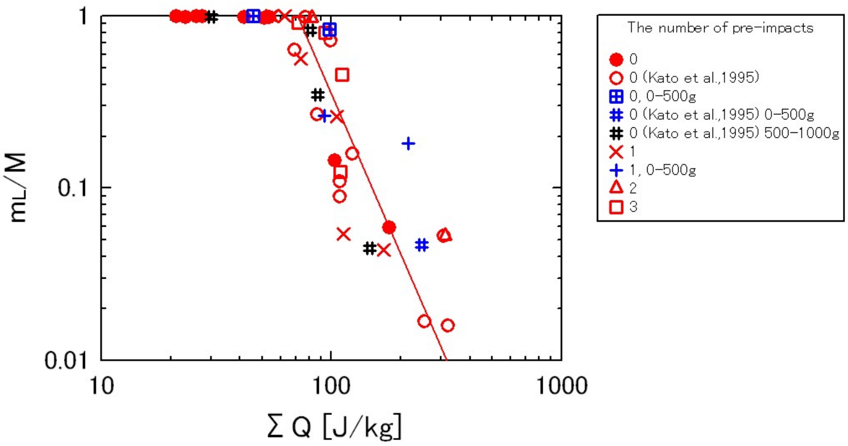
High velocity collisions among icy bodies played an important role in the formation and the evolution of icy planets, icy satellites and KBOs. Actual icy bodies could have experienced multiple-impacts events however most of studies were single-impact experiments rather than multiple ones. In the previous studies related to multiple impacts experiments (Gault et al., 1969; Housen, 2008), it has been reported that cracks induced by pre-impacts have reduced the impact strength of targets. Furthermore, in their experiments, they changed the number of impact times using the same target and the sum of each impact energy in the same set of the experiment was always constant for each target. And, they found that the relationship between the largest fragments and the cumulative energy densities was consistent with that of single-impact experiments. The cracks formed by each impact are not distributed homogeneously in the target. Thus, in the multiple-impacts experiments, it is necessary to quantify the crack density inside the target generated by the pre-impacts. Then, we conducted multiple-impacts experiments to reveal the quantitative relationship between the pre-crack distribution and the impact strength.

Impact experiments were conducted using gas gun installed in a cold room at the Institute of Low Temperature Science, Hokkaido University. An ice projectile was impacted at several times (1 to 4) on the same target, and each impact was conducted on the different surface. The temperature was -10 deg C in the cold room. The impact velocity was from 140 to 480km/s. The projectiles had a cylindrical shape and the mass was 1.6 g. The target was cube made of polycrystalline water ice, and the mass was from 240 to 1280 g. To quantify the crack density of the recovered targets we measured P and S wave velocities of the target when they were not disrupted catastrophically. Then, in the next impact experiment, we used it again.

We changed the energy density (Q) of the first shot of each target, and the second shot were done at the same Q. From this experiment, in the case of high Q at the first shot, m_L/M, which is the largest fragment mass normalized by the initial target mass (M), became smaller. Thus, we found that m_L/M of pre-impact targets was much smaller than m_L/M of the previous results derived from the single-impact of icy projectile on ice target (Arakawa et al., 2002). These results suggest that the pre-cracks reduce the target strength, and moreover this mean that the relationship between the pre-cracks and the target strength strongly depends on the impact record of the target. On the other hand, the size distribution of fine fragments whose m/M, the fragment mass normalized by M, were less than 10^{-4}, was constant regardless of the number of impacts. This suggests that there is a lower limit of the fragment size affected by the pre-crack.

Furthermore, the relationship between m_L/M and sigma Q (the sum of Q for all impacts) for the targets which experienced multiple-impacts was consistent with that for the intact ice targets. Figure 1 shows the relationship between m_L/M and sigma Q. The vertical axis means the m_L/M and the horizontal axis means sigma Q, and each mark is classified by the number of pre-impact times. In this figure, the value of m_L/M depends on sigma Q, and the pre-impact and the target mass have few effects on m_L/M. These data were fitted by a power law equation and we obtained the empirical formula described by m_L/M=7.8 times $10^5 Q^{-3.2}$.

Elastic wave velocities for the recovered targets were measured and they were found to decrease with the increase of the crack density, and this relationship was theoretically discussed by O'Connel and Budiansky (1974) and they showed the theoretical equation showing the relationship between the crack density and an elastic body. By using this equation in this study, we found that the crack density linearly increased with sigma Q regardless of the number of impacts


1
0.1
0.01
10
100
1000
mL/M
∑ Q [J/kg]
The number of pre-impacts
0
0 (Kato et al.,1995)
0, 0-500g
0 (Kato et al.,1995) 0-500g
0 (Kato et al.,1995) 500-1000g
1
1, 0-500g
2
3