A TEMPERATURE RISE ASSOCIATED WITH LOW VELOCITY IMPACT EXPERIMENTS;
T. Ishibashi, S. Kitabayashi, H. Azuma, N. Fujii and K. Sangen, Dept. of Earth Sciences, Faculty of Science, Kobe University, Kobe 657, Japan

Introduction

To estimate the temperature rise by the low velocity (from 10 to 100m/sec) impact experiments is important to examine the solidification processes and the weak thermal metamorphism of the growing planetesimals, which should have been loosely consolidated aggregates initially. Due to the mutual collision, a sequence of the local temperature rise and the cooling would cause the increase of the mechanical strength. Especially, redistribution of grain boundary existing material with low melting point such as H_2O ice and troilite in the grain boundary played the role as binding material(1),(2).

Experimental procedure

In order to perform the low velocity impact experiments, we used a newly developed accelerator using an archery-bow(3) (Figure 1), which consists of the fixed archery bow(A), the arrow with a projectile(B), the collimating pipe(C), the stopper(D) and the velocity detector(E).

Using the accelerator, under one atmosphere and room temperature, a stainless steel sphere of 6.36mm diameter and 1.07g mass has been collided to the flat surface of a fixed target made of a cement block(G) with 100 x 40 mm^2 area and 24mm thickness. The bulk density of the cement block is $2600 kg/m^3$. The impact velocity varies from 14.5 to 46.5 m/sec.

To measure the temperature rise in the target, a chromel-alumel thermocouple of 0.1mm diameter is used(H). To avoid probable atmospheric temperature disturbance, and the direct damage of the thermocouple, the thermocouple junction is buried in the target. The distance between the thermocouple junction and the impact point varies from 1 to 11 mm.

Generated heat and temperature rise

Figure 2 shows an example of the temperature rise profile in the target versus time in the case that the impact velocity is 37.0m/sec and the distance, d, between the impact point and the thermocouple is 5.6mm. Tmax and tr are the maximum temperature rise and the time required to reach Tmax, respectively, which are measured in order to obtained the generated heat. We tentatively approximate to estimate Q, as the heat conduction in the semi-infinite medium from the instantaneous point source, Q. That is

$$2Q = \rho_t \cdot C_p \cdot (2\sqrt{\pi \cdot k \cdot e})^3 \cdot t_r{}^{3/2} \cdot T_{max}$$

where , and are the thermal diffusivity, the heat capacity and density of the target, respectively(5). Figure 3 shows the deduced temperature rise from the product of Tmax and d^3, as a function of the impact velocity. The temperature rise become higher than 50 K at the impact velocity of 40 m/sec, so that the local melting of H_2O ice could occur. Q/Ei and Er/Ei as a function of the impact velocity shown in Figure 4. Ei and Er are the initial and the rebound energy of the projectile. Large part of the initial energy is spent as heating.

Further investigation will be needed to perform these experiments with various materials such as loosely consolidated silicate aggregates and ice for projectiles and targets.

Low velocity impact experiments
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Reference

(1)Fujii,N., M.,Miyamoto and K.,Ito, Proc. 11th ISAS Lunar Planet. Symp., 262-267, 1978. (2)Fujii, N., Ito, K. and Miyamoto, M., Proc. 12th ISAS Lunar Planet. Symp., 145-150, 1979. (3)Ishibashi,T., S.,Kitabayashi, H.,Azuma, N.,Fujii and K.,Sangen, Proc. 21st. ISAS Lunar and Planetary Symposium, 262-267, 1989. (4)Careslaw, H. S. and J. C. Jaeger, Conduction of heat in solids, Chap.10, 510 pp., 1959.

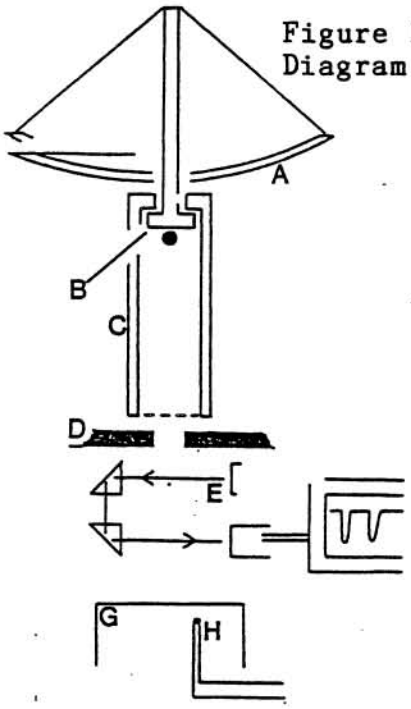

Figure 1
Diagram of Accelerator.

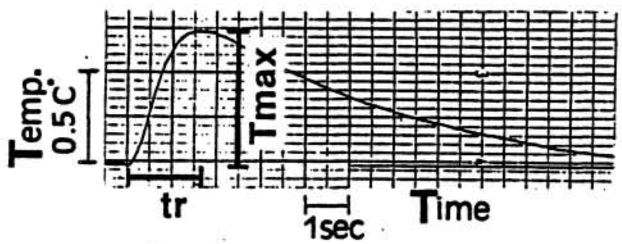

Figure 2
Example of temp. rise.

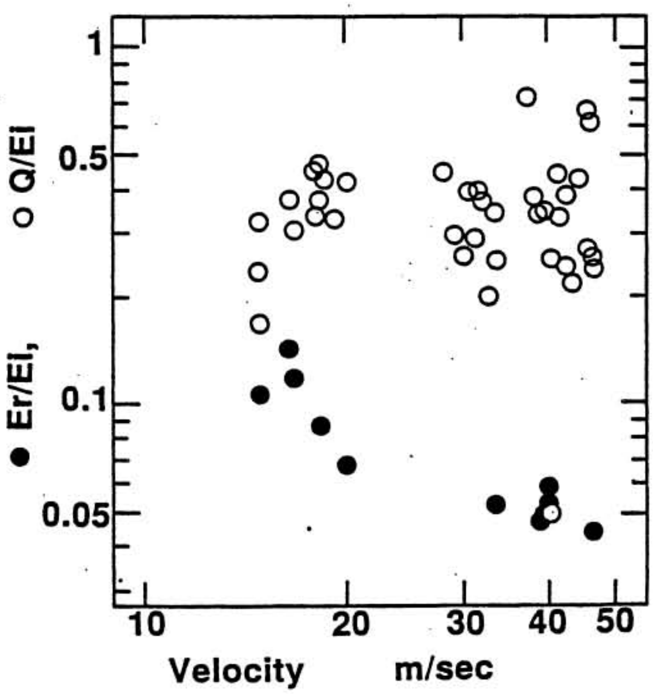

Figure 4
Energy partition.

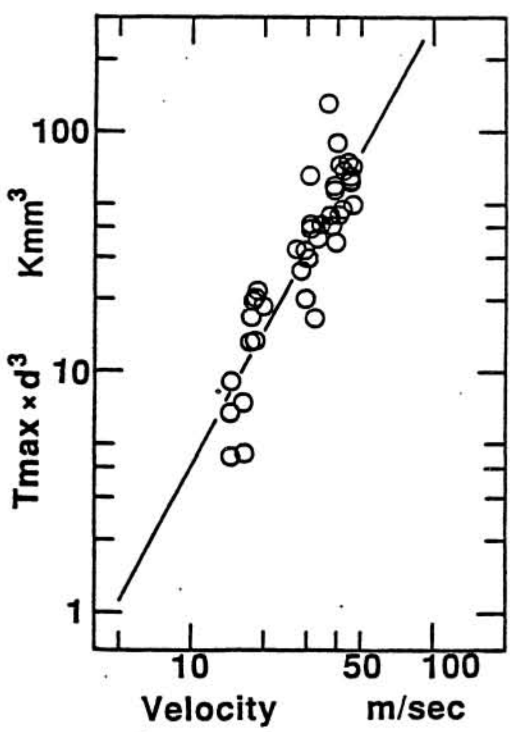

Figure 3
Deduced temp. rise.