Measurements of post shock temperature of impact crater formed on porous ice

*Haruka Sasai[1], Minami Yasui[1], Masahiko Arakawa[1], masato nakamura[1]

1. Kobe University

Background

Recent planetary explorations and astronomical observations focus on the discovery of organic matters on planets and exoplanets because it might be closely related to the origin of lives on the earth. According to the study of primitive meteorites, organic matters in the meteorite parent bodies could react with liquid water and might produce amino acids etc. In the case of comets, a comet nucleus consists of porous ice, which is made of fine grained ice including silicates, organic matters, and carbon dusts, and these comet nuclei could be collided each other to form the impact crater. The shock-compression caused by the crater formation could provide the high temperature and high pressure condition so that various chemical reactions might be accelerated in the warter pool. The shock metamorphism related to organic materials has been studied by Deep Impact Mission on the comet Tempel 1 and by the amino acids polymerization experiments (Sugihara, H. and Mimura, K. (2015)). The post shock heat by the shock compression might cause the existence of liquid water, and it would be very important for chemical evolution of organic matters on icy bodies. Additionally, the post shock heat could cause vaporization of volatile substances to change chemical compositions of the surface. Previous studies on the shock temperature rise investigated the shock temperature of vaporized gases through an analysis of impact flash. But, there was no experiments which directly measured the temperatures of the interiors of the target. Thus, we measured the post shock temperature around the impact crater formed on the snow targets simulating porous icy bodies, and studied whether high-velocity impacts could produce liquid water or not on porous icy bodies.

Experiments

The target porosity was changed from 50 to 60%, and the targets were sintered during 2 to 6 days at < -20℃. The snow target was prepared in a cold room (-15℃) by using several hundred mm ice particles: they were made from water ice blocks crushed into small pieces and sieved to sort particles size below 710 mm. These particles were filled into the acrylic container uniformly and compacted to the specific porosity. Before the compaction, K-type thermocouples with the diameter of 0.127 mm (response speed of 10 ms) were installed into the target at the position of 10-15 mm from the top and 0-15 mm from the center. Impact experiments were conducted by using a two-stage light gas gun set at a cold room (Kobe Univ). Spherical Al and nylon projectiles with the size of 2mm were impacted at the velocity of ~4 km/s. The snow target was set in a large vacuum chamber evacuated below 240 Pa. The post shock temperatures on the snow target were recorded by using a data logger. The entrance of the acrylic container was covered by a thin plate to collect impact ejecta. After the experiment, we observed the crater morphology and especially studied the crater wall in order to check the evidence of molten water.

Results
The recovered targets showed a typical crater morphology found in the strength regime: all craters consisted of two parts, spall part and pit part. Ice agglutinates (mixture of broken and molten projectile and molten ice) were found on the crater wall and near the bottom of the crater. The post shock temperature rise was observed to be from 4 K to 20 K, and the temperature rise strongly depended on the location of thermocouples. Especially around the ice agglutinates, the temperature was found to rise over 0℃, and it showed us that the phase transition from ice to liquid water occurred. We show an example of the temperature rises in the figure; the impact moment is set to be 0 ms, and the legend indicates the distances from the ice agglutinates. The temperature rise is larger as the distance is closer to the ice agglutinates. At the position of 0.0 mm, the temperature reached the maximum in several 10 ms.

Keywords: crater, ice, post shock temperature, porous