The Surviving Rate of Organic Materials after the Cometary Impacts

*Taiki Suzuki[1,2], Takashi Shibata[2], Natsuki Hosono[3]

1. Astrobiology Center, 2. National Astronomical Observatory of Japan, 3. Japan Agency for Marine-Earth Science and Technology

While it is widely accepted that the first life has emerged through the chemical evolution with simple organic materials on the early Earth, the origin of organic materials is still controversial. On the early Earth, a large amount of material is believed to have been delivered by comets/meteorites, providing the starting materials for the origin of life. Despite the importance, the large objects would not have been decelerated by the atmosphere and subjected to compression heating. The numerical studies discussed the possibility of molecular surviving during the cometary impact (e.g., Chyba et al. 1990; Blank et al. 1997; Pierazzo & Chyba 1999). These studies suggested that the extreme pressure and the obliqueness of the impact may increase the surviving rate of the organic molecules.

However, the previous numerical studies employed the simple method by reducing the dimension to 2D, or by assuming the relationship between the obliqueness and the temperature. In the poster, we present the latest result of the 3D simulation of oblique impacts utilizing DISPH (Density Independent Smoothed Particle Hydrodynamics) code. A supercomputer named XC50 and the Framework for Developing Particle Simulators (FDPS) enabled us to solve the three-dimensional impacts without any assumption for the obliqueness. The comet and the sea are composed of the 8200 and eight million particles, respectively. The cometary radius is fixed to be 1 km, and the dependency of the temperature on the obliqueness and the initial velocity are investigated. During the simulation, the physical parameters of all particles are traced through five seconds after the impacts. We name the particles with the peak temperature less than 1200 K as the low-temperature particles, where the organic materials may survive. As the results of our calculation, the percentage of the low-temperature particles is almost zero if the obliqueness is more than 70 degrees. Still, it increases along with the increase of the obliqueness.

In addition to the percentage of low-temperature particles for the different obliqueness, we consider the probability of impacts with different obliqueness to obtain the surviving rate for the organic materials. Then, we estimated the surviving rate of the organic materials to be 2 percent. If this is the case, comets could have provided organic materials more efficiently than the interstellar dust particles and other formation processes on the early Earth. Our result suggests that cometary impact may have been the primary source to provide organic materials to the early Earth.

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