

初期地球における隕石衝突による核酸塩基とアミノ酸の生成 Formation of nucleobases and amino acids by meteorite impacts on early Earth

古川 善博^{1*}; 中沢 弘基¹; 関根 利守³; 小林 敬道²; 掛川 武¹

FURUKAWA, Yoshihiro^{1*}; NAKAZAWA, Hiromoto¹; SEKINE, Toshimori³; KOBAYASHI, Takamichi²;

KAKEGAWA, Takeshi¹

¹ 東北大学地学専攻, ² 物質・材料研究機構, ³ 広島大学理学研究科地球惑星システム学専攻

¹Department of Earth Science, Tohoku University, ²NIMS, ³Department of Earth and Planetary System Science, Hiroshima University

Emergence of biologically important molecules on the prebiotic Earth was a critical step for the origins of life. Miller-Urey type synthesis was once demonstrated the formation of these molecules, such as amino acids and nucleobases. However, reduced atmospheres replicated in those experiments are not realistic considering hot accretion of primitive Earth and hence, this raised questions about how such biologically important molecules were formed. Impact-induced reaction is a potential process that provides these molecules on the early Earth. Formation of a few simple amino acids, amines, and carboxylic acids has been demonstrated in experimental simulation of impacts [1-3]. In this presentation, we report the formation of biologically important organic molecules in experiments simulating reactions induced by extraterrestrial objects impacting on the early oceans. The products contained cytosine and uracil, which are nucleobases found in both DNA and RNA. Proteinogenic amino acids, glycine, alanine, serine, aspartic acid, glutamic acid, valine, leucine, isoleucine, and proline, were also formed as well as non-proteinogenic of β -alanine, sarcosine, α -amino-n-butyric acid, and β -aminoisobutyric acid. Furthermore, methylamine, ethylamine, propylamine, and butylamine were found in products. These organic molecules were formed from impact-induced reactions from iron, nickel, forsterite, water, and ammonium bicarbonate. The yields of produced organics were dependent on the amounts of both metallic iron and ammonium bicarbonate in the starting materials. Estimates based on the experimental results suggest that the formation rate of biologically relevant organics by impacts exceeded the rate supplied by carbonaceous chondrites and was comparable to the flux of interplanetary dust particles (IDPs), although the concentrations of such organics in IDPs remains unclear. These results significantly expand the availability of building blocks of life on the prebiotic Earth.

[1] Furukawa, Y., T. Sekine, M. Oba, T. Kakegawa, and H. Nakazawa (2009), Biomolecule formation by oceanic impacts on early Earth, *Nat. Geosci.*, 2, 627-66. [2] Goldman, N., E. J. Reed, L. E. Fried, I. F. W. Kuo, and A. Maiti (2010), Synthesis of glycine-containing complexes in impacts of comets on early Earth, *Nat. Chem.*, 2, 949-954. [3] Martins, Z., M. C. Price, N. Goldman, M. A. Sephton, and M. J. Burchell (2013), Shock synthesis of amino acids from impacting cometary and icy planet surface analogues, *Nat. Geosci.*, 6, 1045-1049.

キーワード: 生命の起源, アストロバイオロジー, アミノ酸, 隕石, 衝突, 有機物

Keywords: Origins of life, Astrobiology, Amino acid, Meteorite, Impact, Organic compounds