Formation of life's building blocks by mteorite impacts

Y. FURUKAWA[1], H. NAKAZAWA[2], T. SEKINE[3], T. KOBAYASHI[2], T. KAKEGAWA[1]

[1]Department of Earth Sciecne, Tohoku University, Sendai, Japan (*Correspondance: furukawa@m.tohoku.ac.jp)

[2]National Institute for Materials Science, Tsukuba, Japan

[3]Department of Earth and Planetary Systems Science, Hiroshima University, Higashi-Hiroshima, Japan

Emergence of biologically-important molecules on the prebiotic Earth was a critical step for the origin of life. Miller-Urey type synthesis was once demonstrated the formation of these molecules. However, strongly reduced atmospheres replicated in those experiments are not consistent with hot accretion of primitive Earth and hence, this raised questions about how such biologically-important molecules were formed. Influx of extraterrestrial objects provided large amounts of reductants such as metallic iron and carbon to the early Earh. Impacts of these objects promote chemical reactions between meteoritic minerals and terrestrial materials and were suggested to form reduced materals such as hydrogen, ammonia, and carbon monoxide [1]. Furthermore, glycine, the smallest amino acid, was formed from elemental carbon, water, gaseous nitroge, and metallic iron with nickel in eperimntal simulation of impact-iunduced reactions. When ammonia was used as nitrogen source in addition to gaseous nitrogen, formation of a glycine, amines, and carboxylic acids has been demonstrated in experimental simulation of meteorite impacts [2]. When bicarbonate was used as the carbon source instead of elemental carbon, we found that pyrimidine nucleobases, cytosine and uracil, which compose DNA and RNA, were formed by this impact. Furthermore, proteinogenic amino acids, glycine, alanine, serine, aspartic acid, glutamic acid, valine, leucine, isoleucine, and proline, were also found as well as non-proteinogenic of β-alanine, sarcosine, α-amino-n-butyric acid, and β-aminoisobutyric acid. 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. These results would expand the availability of building blocks of life on the prebiotic Earth.

[1] Furukawa et al., (2013) Icarus 231, 77–82 [2] Furukawa et al., (2009), Nat. Geosci., 2, 62–66.