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隕石海洋衝突によるアラニンの化学進化と酸素分圧の影響
Effect of oxygen fugacity in chemical processes of alanine during oceanic impacts of meteorites

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The biomolecules on the Earth are thought either to have come from the extraterrestrial parts carried with flying meteorites or to have been formed on the Earth from the inorganic materials through given energy. From the standpoint to address the importance of impact energy, it is required to simulate experimentally the chemical reactions during impacts, because violent impacts may have occurred 3.8-4.0 Gyr ago to create biomolecules initially. It has been demonstrated that shock reactions between ocean and meteoritic constitutions can induce locally reduction environment to form bioorganic molecules such as amino acid (Nakazawa et al., 2005; Furukawa et al., 2009). We need to know possible processes how further chemical evolutions proceed by repeated impacts and how more complicated biomolecules are formed.

In this study, we carried out shock recovery experiments to investigate the chemical reactions of alanine in aqueous solutions and the effect of oxygen fugacity. Experiments were carried out with a propellant gun. We used alanine labeled by ^{13}C to distinguish products from contaminants. Sample of aqueous solution immersed in olivine or hematite powders, sealed in a stainless steel container, was used as a target. The sample space has air gap behind the sample. The powder, solution, and air correspond to meteorite, ocean, and atmosphere on early Earth, respectively. Two powders of olivine and hematite can keep the oxygen fugacity low and high during experiments, respectively. After shots, the steel containers, after cleaned, were immersed into liquid nitrogen for sample solution to be frozen and then we drilled on the impact surface to extract water-soluble components from the sample using pure water in a beaker. After that, water-soluble components were analyzed by LC/MS for four amino acids (glycine, alanine, valine, and phenylalanine) and four amines (methylamine, ethylamine, propylamine, and butylamine).

The results indicate the formation of decomposition products (glycine, methylamine, ethylamine, and propylamine) of alanine and butylamine as a new biomolecule. However, the results did not detect any formation of valine and phenylalanine those could be expected to form by reactions. Glycine and some amines were detected in samples under low oxygen fugacity, while these molecules were hardly detected in samples under high oxygen fugacity. Therefore, oxidative conditions are not preferable to the formation of biomolecules. On the other hand, the present experimental results suggest that the survival rate of alanine depends on pressure and temperature but that it is not dependent on oxygen fugacity. In applying the present results to actual meteorite impacts, the physical condition during impact is a key factor in chemical reactions, although it also must be taken into account the heterogeneous distribution of impact energy in an impact that may cause a significant effect on the chemical reactions.