

Formation of organic compounds by hypervelocity impacts on terrestrial planets

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Synthesis of life's ingredients from reduced carbon and nitrogen sources have been shown in many previous early Earth simulation experiments. Impact events have been regarded as one of such events that synthesize amino acids and nucleobases with a reduced nitrogen source, NH_3 . However, such reduced species are regarded as minor compounds in Hadean ocean and atmosphere. Formation of amino acids from the abundant C and N sources, i.e., CO_2 and N_2 , have only been demonstrated by spark discharge, previously. Thus, it remains unclear whether amino acids form in other geochemical events.

We conducted shock-recovery experiments to simulate an impact-induced reaction associated with hypervelocity impacts of Fe-bearing meteorites on ocean with CO_2 - N_2 atmosphere. The typical starting materials contains iron, nickel, forsterite, water, sodium bicarbonate, and gaseous nitrogen. Shock wave was provided by an impact of metal disc plate on a metal container containing the starting materials. The products were analyzed with liquid chromatography mass spectrometry. Powder X-ray diffractometer was used for mineral identification.

The product contained many organic compounds. These yields depend on the compositions of redox state of the minerals in the starting materials. The most reduced mineral mixture provided the highest organic yields. Metallic iron was oxidized to iron carbonate, siderite.

The preset results indicate that ancient impact events formed organic compounds including essential ingredients of life from the major C and N species on prebiotic Earth. This results also suggests that this type of synthesis was happened on Noachian Mars, since major component of atmosphere on Noachian Mars is estimated as oxidized C and N, i.e., CO_2 and N_2 .

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