The Nature of Extraterrestrial Amino Acids in Carbonaceous Chondrites and Links to Their Parent Bodies

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Meteorites and samples returned from asteroids and comets provide an important record of the physical and chemical processes that occurred in the early solar system and represent some of the oldest solid materials currently available for laboratory analyses. The delivery of organic matter by extraterrestrial material to the early Earth could have been an important source of complex prebiotic organic molecules available for the emergence of life. Analyses of primitive carbonaceous chondrites over the last five decades have revealed a major insoluble organic component [1,2], as well as a complex and highly diverse suite of soluble organic molecules of prebiotic importance [3,4] that includes carboxylic acids, N-heterocycles, sugars, amino acids, amines, and many other organic molecules that have not yet been identified [5]. Amino acids continue to be a primary focus of many soluble organic analyses in carbonaceous chondrites because (1) these molecules are essential components of life (as the monomers of proteins), (2) they have structural diversity (multiple possible isomers) that can be used to help constrain formation mechanisms and parent body conditions, and (3) most amino acids identified in carbonaceous chondrites are chiral, a property that can be used to distinguish between amino acids of extraterrestrial and terrestrial origins. The degree of parent body hydrothermal alteration has been shown to have a major influence on the formation and destruction of amino acids in carbonaceous meteorites as observed in the measured abundances and molecular distributions [6]. Aqueous alteration in primitive asteroids could have also led to the preferential enrichment of some left-handed amino acids over their right-handed forms, an astounding discovery that suggests that the origin of life on Earth or elsewhere was biased toward left-handed amino acid homochirality [7,8]. This talk will give an overview of what is known about the amino acid composition of carbonaceous chondrites, present some key unanswered questions, and discuss how the analysis of samples returned from asteroids Ryugu and Bennu will further advance our understanding of parent body chemistry and potential contributions from carbonaceous asteroids to the origin of life on Earth or elsewhere.

References

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