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Extraterrestrial amino acids and related chemical precursors in a sample returned from asteroid (101955) Bennu

DANIEL P. GLAVIN[1], HANNAH L. MCLAIN[1,2], ERIC T. PARKER[1], JASON P. DWORKIN[1], JOSE C. APONTE[1], JAMIE E. ELSILA[1], ANGEL MOJARRO[1,3], DANIELLE N. SIMKUS[1,2], PROF. HAROLD C. CONNOLLY JR., PHD[4,5,6] AND DANTE S. LAURETTA[5]

[1]NASA Goddard Space Flight Center
[2]Catholic University of America
[3]Oak Ridge Associated Universities
[4]Rowan University
[5]Lunar and Planetary Laboratory, University of Arizona
[6]American Museum of Natural History

Presenting Author: daniel.p.glavin@nasa.gov

Introduction and Methods: Samples collected from the surface of carbonaceous B-type asteroid Bennu and returned to Earth by the OSIRIS-REx mission in September 2023 provide a pristine record of the chemical processes that occurred in the early solar system. We hypothesized [1] that Bennu contains prebiotic organic matter, including amino acids that could have contributed to the emergence of life on Earth. To test this, we investigated the hot water extract (100 °C for 24 h) of a ~25 mg sample of Bennu aggregate (OREX-803001-0) taken from inside the spacecraft's sample collector. An aliquot of the extract supernatant was analyzed directly for free ammonia, C_1-C_6 amines, and amino acids by AccQ·Tag derivatization and liquid chromatography with UV fluorescence detection and time of flight–mass spectrometry (LC-FD/ToF-MS). Another portion of the extract was acid-hydrolyzed and desalted prior to derivatization with *o*-phthaldialdehyde/*N*-acetyl-L-cysteine to determine the total abundances of the C_2-C_6 amino acids and D/L ratios of chiral amino acids using LC-FD/ToF-MS [2].

Results and Discussion: A total of 28 individual amino acids and 16 amines were identified in the Bennu extract, including 13 of the 20 standard protein amino acids found in biology, as well as all C_3-C_5 amino acid isomers. The terrestrially rare non-protein amino acids isovaline and α-aminoisobutyric acid were also detected. Furthermore, all chiral non-protein amino acids were present as racemic mixtures (D/L ~ 1). The total abundance of extraterrestrial amino acids in Bennu (~70 nmol g^{-1}) falls within the range of aqueously altered carbonaceous chondrites [2]. However, the high free ammonia abundance (~13,600 nmol g^{-1}), elevated amine levels (~1,100 nmol g^{-1}), and amino acid distribution in Bennu dominated by glycine is distinct from the most aqueously altered type 1 chondrites and the C-type carbonaceous asteroid Ryugu [3]. The unique amino acid and amine distributions of Bennu may reflect a novel asteroidal chemical composition and/or parent body alteration history.

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References: [1] Lauretta D. S. et al. (2023) arXiv [astro-ph.EP] 2308.11794. [2] Glavin D. P. et al. (2011) *MAPS* 45, 1498-1472. [3] Parker E. T. et al. (2023) *GCA* 347, 42-57.