

**EXTRATERRESTRIAL AMINO ACIDS IN UREILITES INCLUDING ALMAHATTA SITTA.** AS Burton, DP Glavin, MP Callahan and JP Dworkin. Goddard Center for Astrobiology, NASA Goddard Space Flight Center, Greenbelt, MD 20771, [aaron.s.burton@nasa.gov](mailto:aaron.s.burton@nasa.gov).

**Introduction:** Ureilites are a class of meteorites that lack chondrules (achondrites) but have relatively high carbon abundances, averaging ~3 wt %. Using highly sensitive liquid chromatography coupled with UV fluorescence and time-of-flight mass spectrometry (LC-FD/ToF-MS), it was recently determined that there are amino acids in fragment #4 of the Almahata Sitta ureilite [1]. Based on the presence of amino acids that are rare in the Earth's biosphere, as well as the near-racemic enantiomeric ratios of many of the more common amino acids, it was concluded that most of the detected amino acids were indigenous to the meteorite. Although the composition of the Almahata Sitta ureilite appears to be unlike other recovered ureilites, the discovery of amino acids in this meteorite raises the question of whether other ureilites may also contain amino acids. Herein we present the results of LC-FD/ToF-MS analyses of: a sand sample from the Almahata Sitta strewn field, Almahata Sitta fragments #25 (an ordinary H5 chondrite) and #27 (ureilite), as well as an Antarctic ureilite (Allan Hills, ALHA 77257).

**Results and Discussion:** Amino acids were detected in all of the meteorite samples. The approximate level of exposure to Earthly contaminants that each sample experienced can be ascertained by comparing the D/L ratios of the chiral proteinaceous amino acids of the meteorite to the terrestrial sand sample. For example, Almahata Sitta fragment 4 appears to be almost pristine, as it has nearly equal amounts of L- and D-glutamic acid and alanine, while the sand shows a higher abundance of the L-enantiomers of these amino acids. Conversely, the ALHA 77257 ureilite appears to have experienced an appreciable degree of terrestrial contamination, as it has a significant L-excess for all of the chiral amino acids.

The 4-carbon ( $C_4$ ) amino acids  $\beta$ -aminobutyric acid ( $\beta$ -ABA) and  $\alpha$ -aminoisobutyric acid are present in 1.5-fold or greater abundances in the meteorite samples compared to the sand. Additionally,  $\beta$ -ABA is racemic within the measurement error. These data, coupled with the observation that all of the biological amino acids are present in greater concentrations in the sand than in any of the meteorites samples, makes a compelling case that these amino acids are indigenous to the meteorite, and, therefore, of extraterrestrial origin. A number of 5-carbon ( $C_5$ ) amino acids fit these criteria as well, including isovaline, 3-aminopentanoic acid, 3-amino-2,2-dimethylpropanoic acid, 4-amino-2-methylbutanoic acid and 4-amino-3-methylbutanoic acid.

An intriguing feature of the  $C_5$  amino acid data is the distribution of amine position among the different meteorites (*i.e.*,  $\alpha$ ,  $\beta$ ,  $\gamma$  or  $\delta$ ). Despite all being classified as ureilites, fragment #4, #27 and ALHA 77257 are very different when considering their dominant amine positions (see Figure 1). Furthermore, the greatest similarity is observed between Almahata Sitta fragment #27 and the ordinary chondrite (non-ureilite) fragment #25. This suggests that the amino acids found in fragment #4 and fragment #27 were formed at different times within the same parent body, or that they originate from separate parent bodies. In contrast, despite fragments #25 and #27 having different petrological classifications, their amino acids may have had similar origins or diffused from one fragment into the other.

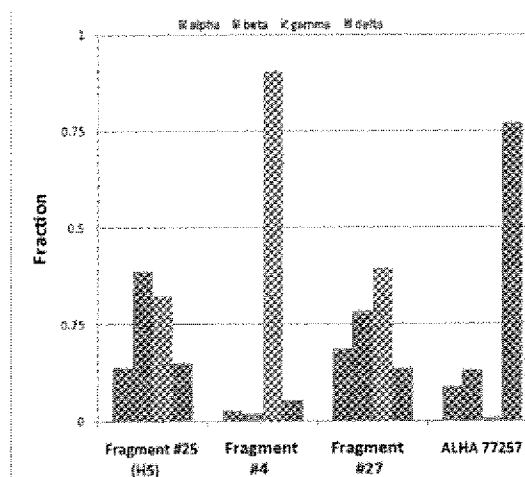


Figure 1. The relative abundances of the 5-carbon amino acids as a function amine position

**Conclusion:** The varied amino acid compositions between the ureilites studied here argues for the presence of more than one ureilite in the asteroid 2008 TC<sub>3</sub>.

**References:** [1] Glavin DP et al (2010) *Meteoritics & Planet. Sci.*, 45, 1695–1709.

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