SIMULATING AMINO ACID SYNTHESIS IN METEORITIC PARENT BODIES. Ralph E. Pudritz[1], Alyssa K. Cobb[2], and Ben K.D. Pearce[3], [1]Origins Institute, McMaster University, ABB 241, 1280 Main St, Hamilton, ON, L8S 4M1, Canada (pudritz@physics.mcmaster.ca), [2]Northrop Grumman Corporation, 3535 Northrop Grumman Point, Colorado Springs, CO 80916 (cobbak@mcmaster.ca), [3]University of British Columbia, Department of Physics & Astronomy, 6224 Agricultural Rd, Vancouver, BC, (ben.pearce@alumni.ubc.ca)

Introduction: The origin of amino acids on young planets is one of the most basic questions on the origins of life. The class of meteorites known as the carbonaceous chondrites has high content of water and organic materials, including amino acids. It is well known that these extraterrestrial sources could have contributed a very signicant fraction of the organics present on the young Earth's surface [1]. Here we compute the synthesis of proteinogenic amino acids in the warm interiors of planetesimals within a few million years of their formation, and compare to the meteoritic record.

A good example of the extensive chemical analysis of meteorites for biomolecules for the famous Murchison meteorite [2]. We recently completed an extensive collation of available meteoritic data on amino acid abundances and relative frequencies in carbonaceous chondrites[3]. This broad spectrum view of amino acid abundance data provided us with the constraints that we now use in this computational study to reproduce these observed abundance patterns. The carbonaceous chondrites sub-classes CI, CM, CR, CV, and CO, in particular, are all known to contain high concentrations of water and organics, and their petrologic types vary from 1-3, ranging from the greatest degree of aqueous alteration (1) to those that most resemble the solar nebula in which they formed (3).

The parent bodies of meteorites namely planetesimals which are typically up to 50 - 100 km in size, were formed during the the earliest stages of the formation of the solar system. Their composition consists of rock and ice together with various simple molecules (eg. HCN and ammonia) and organics (eg. formaldehyde) that were inherited from the icy, dusty materials in disks and interstellar gas. Such bodies also contained various radionuclides whose decay heated their interiors up to 150^{o} C for several million years. Experimental work [4] has shown that carbonaceous chondrites like Murchison (also-called CM2-type) may be explained by a Strecker-type synthesis wherein aldehyde molecules (such as formaldehyde) in the presence of water, ammonia and HCN give rise to amino acids (such as glycine). Based on published reaction rates [5], it is a good assumption that processes will have achieved thermodynamic equilibrium, making the Gibbs free energy minimization a desirable approach. Our model assumes this chemical equilibrium, and outputs a series of amino acid concentrations which minimize the Gibbs free energy. Early theoretical work on the synthesis of amino acids in hydrothermal environments used this approach to show that the synthesis of amino acids via a Strecker synthesis-like pathway is energetically favorable [6][7].

We model parent body interiors using temperatures and pressures cited in previous studies [8] and cometary abundance data of organics for the initial concentrations in our model. We use modeling software called ChemApp to perform a global minimization of Gibbs energy and calculate a theoretical yield of amino acids formed by Strecker reactions.

Results: Our modelled CM-type and CR-type total amino acid abundances at temperatures less than 311 ^{o}C remain near 7x10^{5} parts-per-billion (ppb), which is in agreement with the average observed abundance in CR2 meteorites of 4±7x10^{5}, but approximately an order of magnitude higher than the average observed abundance in CM2 meteorites of 2±2x10^{4}. A decrease in total water content in the meteorite parent body can explain the discrepancy between the CM-type model computations and the observed amino acid abundances in CM2 meteorites. There is a sharp drop that occurs in total amino acid abundance at the liquid-to-gas phase transition of the aqueous solution that we attribute to the decline in thermodynamic favourability once in a gaseous phase mixture. Also, the observed and theoretical frequencies of amino with respect to glycine match to well within an order of magnitude in both classes, at a temperature of 150^{o} C. The degradation of lysine and threonine for CM-type relative frequencies and of isoleucine for CR-type relative frequencies by 250^{o} C and 300^{o} C suggests a thermodynamic explanation based on the limited range of internal meteorite parent body temperatures. Finally, we propose that the amino acid abundances of meteorites are primarily dependent on the water content of planetesimals originating from different protoplanetary disk radii.

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