AMINO ACID DESTRUCTION CONSIDERATIONS FOR IN SITU MEASUREMENTS OF ENCELADUS AND OTHER OCEAN WORLDS. A. A. Monroe[1], C. R. Glein[2], A. D. Anbar[1,3], E. L. Shock[1,3], and J. I. Lunine[4], [1]School of Earth and Space Exploration, Arizona State University, PO Box 871404, Tempe, AZ 85287, aamonroe@asu.edu, anbar@asu.edu, eshock@asu.edu, [2]Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78228, cglein@swri.edu, [3]School of Molecular Sciences, Arizona State University, PO Box 871604, Tempe, AZ 85287, [4]Cornell Center for Astrophysics and Planetary Science, 402 Space Sciences, Cornell University, Ithaca, NY 14853, jlunine@astro.cornell.edu.

Introduction: There is great interest in using extraterrestrial amino acid abundances in the search for life. However, amino acids are a common abiotic product of organic cosmogeochemistry and simulated astrochemistry. For example, amino acids are found both in extracts of carbonaceous chondrite meteorites [1] and ices irradiated to simulate the environment of the interstellar medium [2,3]. As a result, Enceladus and Europa could contain amino acids formed primordially by processes on planetesimals or ice photochemistry. They may also contain amino acids formed recently by geochemical or biological processes. A first step in using amino acid abundances as a biosignature is to distinguish primordial (accreted) from recently formed amino acids.

Recently formed amino acids can be identified based on their relative stabilities. Knowledge of reaction rates of destruction, racemization, or epimerization of amino acids enables construction of a chronology for a given temperature range as dictated by environment [4]. Here we use chemical kinetics data to estimate rates and timescales of amino acid destruction (e.g., decarboxylation or deamination) on hydrothermally active ocean worlds.

Methods: Temperature constraints are assumed for amino acids in a parcel of liquid water circulating between a rocky core and ocean by way of hydrothermal systems: T_{ocean} = 273 K, $T_{core} \geq$ 323 K [5], $T_{core} \geq$ 363 K [6]. The residence times of a parcel of water in each of two connected reservoirs are related by the relative masses of the reservoirs so long as rates of exchange between them are equal (i.e., the system of two reservoirs is closed). We use calculated ocean and pore water masses from geochemical and geophysical arguments [7,8] to estimate a range of 0.6:1 to 2.5:1 for $m_{ocean\ water} : m_{core\ water}$ on Enceladus.

Amino acid destruction timescales are calculated using analytic solutions to kinetic equations which require rate constants. The Arrhenius equation allows calculation of rate constants not experimentally determined [9-12]. Any Arrhenius parameters not reported were regressed by least squares fit of ln[k] vs. 1/T. This approach has produced racemization timescale estimates for meteoritic amino acids based on assumed asteroidal parent body temperatures [13].

Results and Discussion: The rate of possible abiotic amino acid destruction on an ocean world with hydrothermal activity largely depends on (1) the maximum temperature experienced during hydrothermal circulation and (2) the relative masses of its ocean and core water reservoirs.

Temperatures and Timescales - Temperatures are assumed from the properties of the ocean and hydrothermal systems/core. If Enceladus' core has been fully cracked since its formation [14], the average water parcel may have resided at the elevated temperatures in core hydrothermal systems for approximately 30 to 60 percent of Enceladus' age.

On more massive ocean worlds with larger relative masses of ocean water due to lower rock porosity, parcels of water spend a smaller fraction of total time at the higher temperatures of hydrothermal systems.

Amino Acid Destruction - Different amino acids vary in temperature sensitivity to decomposition and racemization. Among glycine, alanine, serine, aspartic acid/aspartate, and norvaline, aspartate is relatively sensitive to decomposition. Any aspartate detected at Enceladus cannot be primordial, and in situ detection of aspartate would indicate recent (< 1 Myr) production of the amino acid.

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