**Opportunity Title:** Understanding the Formation of Kerogen in Chaotropic & Kosmotropic Environments
**Opportunity Reference Code:** 0120-NPP-NOV23-ARC-Astrobio

**Organization** National Aeronautics and Space Administration (NASA)

**Reference Code** 0120-NPP-NOV23-ARC-Astrobio

**How to Apply** All applications must be submitted in [Zintellect]

**Application Deadline** 11/1/2023 6:00:00 PM Eastern Time Zone

**Description** **Description:**

This project will investigate the early diagenetic processes potentially occurring in terrestrial ecosystems as a means to better understand the early geochemical drivers of the formation and degradation of more recalcitrant classes of organic matter (i.e., lipids and kerogen). We will use laboratory experiments to understand how salt content, concentration and wet/dry cycling to better predict the chemical nature of biogenic organics incorporated into insoluble macro molecular structures. results will have primary relevance to ancient and modern Mars and other salt-rich organics-containing targets in the Solar System such as Enceladus and Europa.

The project's goal is to understand the role of water availability driving the initial formation of recalcitrant molecular biosignatures, namely kerogen, across various salt composition (i.e., chao- and kosmo- tropicity). Microbial communities are dynamic and responsive to chemical and physical environmental factors as a biome experiences seasonal changes throughout the year. These changes can be in water availability, resulting salt evaporites, osmotic pressure oscillations, temperature fluctuations, pH shifts, and light availability. Organic matter that is produced undergoes changes during diagenesis, and some of that organic matter is incorporated into a macromolecular structure called kerogen. Kerogen is defined as insoluble macromolecular organic matter (IMOM) recovered after demineralization and solvent extraction of sedimentary rock. It is the largest repository of preserved organics in terrestrial systems, at an estimated 15 million Gt. In biological systems, kerogen selectively sequesters organic molecules such as proteins, carbohydrates, lipids, and lignin, and protects them from degradation, making kerogen a key target for future life detection missions. During diagenesis, the first step in the breakdown of organic material in the shallow subsurface, many organic molecular components that are biosignatures for various groups or organisms and highly resistant to biochemical degradation, are bound within an IMOM matrix. Typically, longer-chain and/or higher molecular weight organics are reduced to smaller molecular subcomponents and then incorporated into an insoluble macromolecule.

From the biochemical perspective, salt composition and water activity is well known to impact biomolecular interactions since certain salts are known to disrupt hydrogen bonding. Chaotropic agents disrupt hydrogen bonding in aqueous solutions leading to increased entropy (chaos) whereas kosmotropic agents are compounds that promote hydrogen bonding (order). The Hofmeister series dictates the ordering of ions in terms of their ability to stabilize and induce precipitation or aggregation of proteins. A few studies have demonstrated the effects of chao- and kosmotropic agents on the chemistry of labile biomolecules (e.g., mRNA, rRNA, and DNA). Weak chaotropes such as Cl- have been shown to inhibit enzyme and cellular functions and the chaotropic ion (Mg2+) binds to DNA due to its attraction to the negatively charged phosphate backbone. In one study, chaotropic salts were shown to increase the production of unsaturated fatty acids in E. coli due to decreased hydrophobic interactions. This project will also produce improved understanding of community adaptations to salt composition and abundance.

Understanding the drivers of initial kerogen formation in salt-rich settings is crucial for predicting the state of organic matter on Mars and thus the types of instrumentation required to analyze organics and seek molecular biosignatures. This study will attempt to link, for the first time, water availability, salt chemistry,and proto kerogen formation in order to better understand the drivers, timing, and potential for preservation of recalcitrant biomarkers from salt-adapted microbial communities

**Field of Science:** Astrobiology

**Advisors:**

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**Applications with citizens from Designated Countries will not be accepted at this time, unless they are Legal Permanent Residents of the United States.** A complete list of Designated Countries can be found at: https://www.nasa.gov/oiir/export-control.

Eligibility is currently open to:

- U.S. Citizens;
- U.S. Lawful Permanent Residents (LPR);
- Foreign Nationals eligible for an Exchange Visitor J-1 visa status; and,
- Applicants for LPR, asylees, or refugees in the U.S. at the time of application with 1) a valid EAD card and 2) I-485 or I-589 forms in pending status

**Eligibility Requirements**

- **Degree:** Doctoral Degree.