National Aeronautics and Space Administration

FY25 Strategic University Research Partnership (SURP)

Laboratory Characterization of Carbon in Salts: A Study of Ceres Analogs

Principal Investigator: Julie Castillo (400); **Co-Investigators:** Maitrayee Bose (Arizona State University), Lucas Reynoso (Arizona State University)

The goal of this work is to provide an experimental framework to understand preservation of carbon in both organic and inorganic forms in sodium chloride and sodium carbonate salts. The focus is on carbonaceous bodies, and dwarf planet Ceres in particular, but the projected results apply to many large volatile-rich bodies.

We want to probe if carbon (in any form) can be encapsulated and preserved in the sodium chloride and sodium carbonate salts found on the surface of Ceres, and are likely a result of hydrothermal alteration in its interior. Extraterrestrial salts are rarely found within meteorites, because the salts are so easy to degrade, while the meteorites are sitting on the Earth's surface. Hence, this work is novel in that it will develop experimental protocols that can be extended to the study of salt crystals in situ and returned to Earth by future missions.

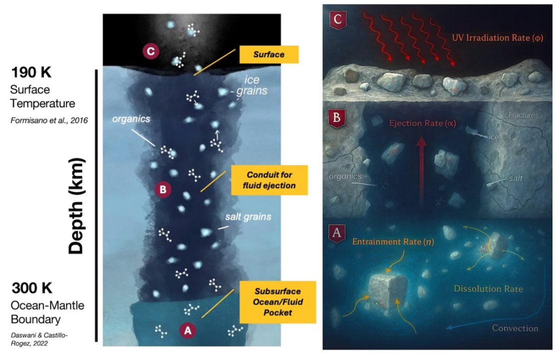

Figure 1. Evaporite emplacement mechanism expected at Ceres, based on observations by the Dawn mission. The salt crystals grow while they transit to the surface and trapped organic compounds in the process. Credit: Lucas Reynoso.

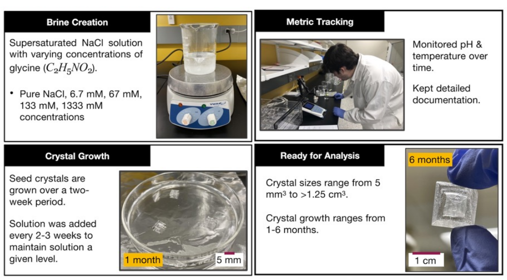

Figure 2. Methodology used for producing simulants of evaporites that emulate the evaporites found on Ceres' surface. The analysis of the sample involves microscopy, Fourier Transform infrared spectroscopy (FTIR), elemental analysis, and gas chromatography flame ionization detector (GC-FID). The latter is used to identify and measure the abundance of organic compounds. These facilities are all available at the partner university (Arizona State U).

Approach and Results:

The methodology used for producing simulants of Ceres evaporites based on their emplacement process (Figure 1) is detailed in Figure 2. It involves growing halite crystals from a solution rich in organic matter. Here, the amino acid glycine ($C_2H_5NO_2$) is used as a first step toward a more detailed study of the incorporation of organic compounds in salts.

A key result from this work is the quantification of glycine incorporated in the salt crystals as a function of solution concentration and growth duration (Figure 3). Analyses show that the amount of glycine trapped in the crystals is linearly proportional to the abundance of glycine in solution. Hence, the analysis of salts returned from a future Ceres mission may tell us about the abundance of organics in solution. However, the amount of glycine decreases with the time spent in solution. Depending on the transfer and emplacement mechanisms, the salt content in organic compounds may be representative of the solution composition (fast transfer) or might be underrepresentative (slower transfer).

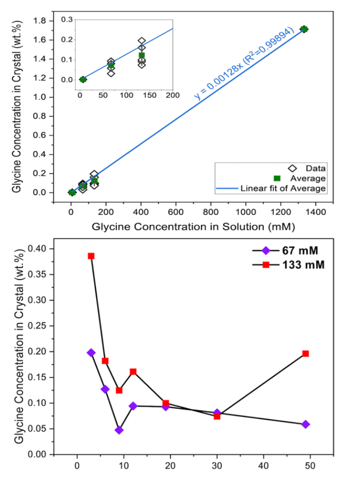

Figure 3. Example of result showing the amount of glycine trapped in the evaporites as a function of the concentration of glycine in solution and of growth duration.

Significance/Benefits to JPL and NASA:

These results have been used to plan for a future Ceres sample return mission, which is one concept in the list of possible missions recommended by the National Academies Committee on Astrobiology and Planetary Science for New Frontiers ($1.2B class) missions. The aforementioned results set a reference content in organic matter in salts, which can be used in the definition of the sampling system, the required sample mass, and of the sample curation.

These results are also relevant to Europa and Enceladus and can be used to plan for future in situ (lander) missions at these bodies, with the goal to characterize salts with in situ techniques. The low abundance in organic compounds reported in this work implies that these future missions will require highly sensitive analytical instruments.

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

RPD-121 Clearance Number: CL#25-4665

Publications:

Lucas R. Reynoso, Maitrayee Bose, Julie C. Castillo-Rogez, Kirtland J. Robinson, and Robert A. Root, Glycine Partitioning into Halite During Crystallization from Ceres Simulant Brines, submitted to *Geochimica et Cosmochimica Acta.*

PI/Task Mgr. Contact Information: 818 640 923
Julie.C.Castillo@jpl.nasa.gov