FY24 Strategic University Research Partnership (SURP)

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

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

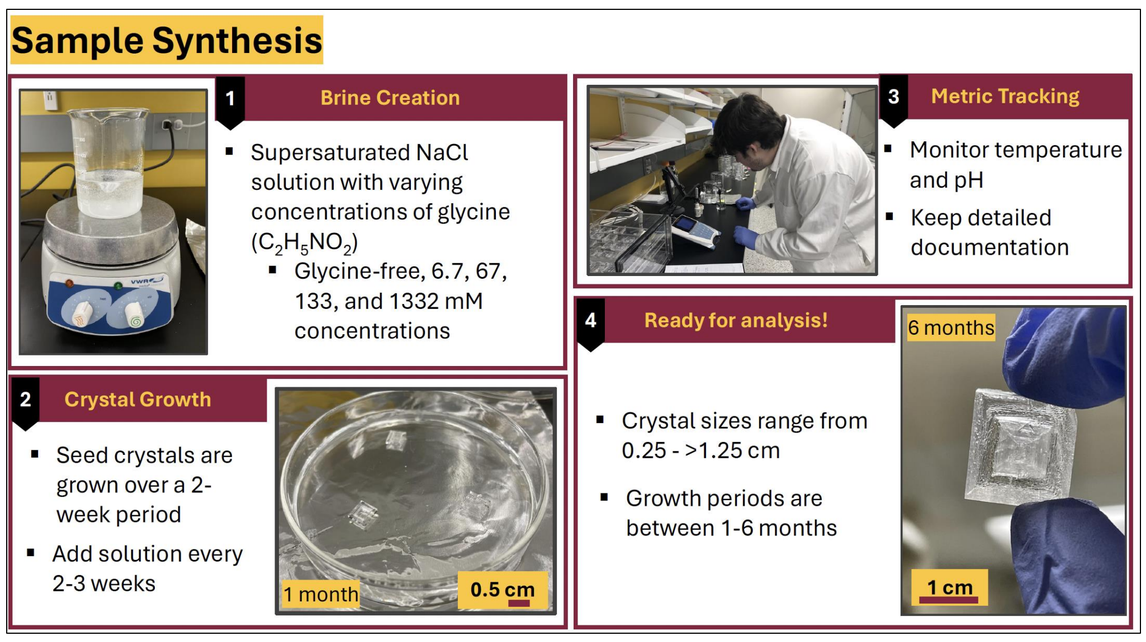
Student Investigators: Lucas Reynoso (Years 1-3)

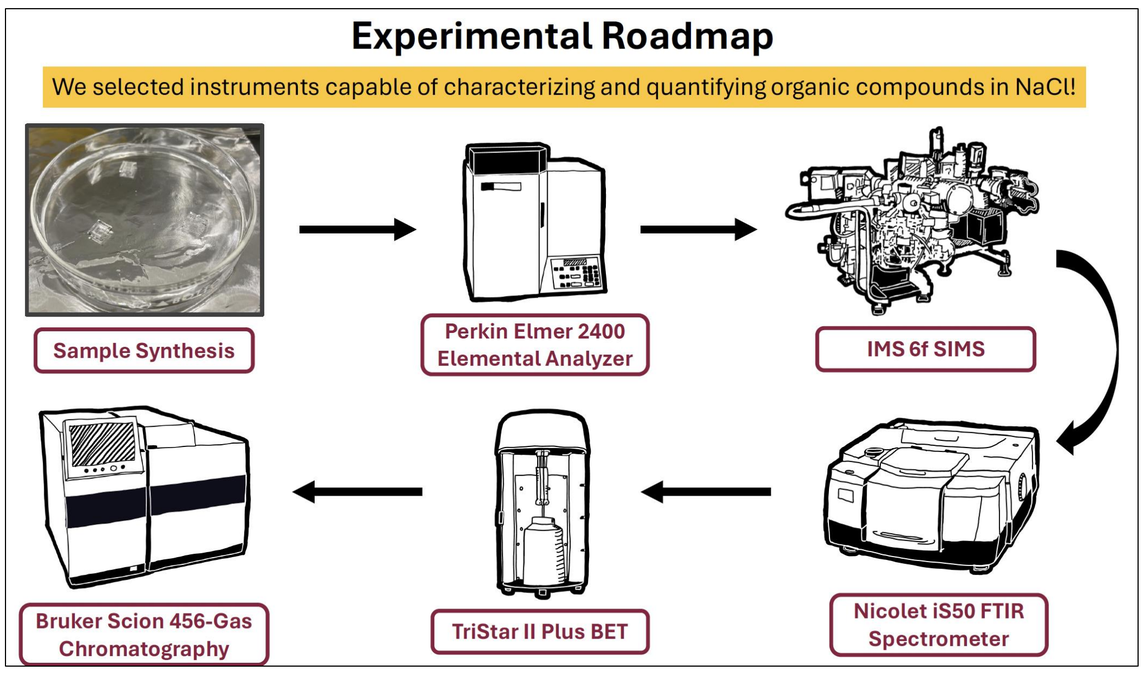
Objectives: The goal of this work is to provide an experimental framework to understand preservation of carbon in both organic and inorganic forms in sodium chloride and sodium carbonate salts. The focus is on carbonaceous bodies, and dwarf planet Ceres in particular, but the projected results apply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

How do brines and organics freeze together? Is there a kind of carbonaceous matter that would preserve its chemical and physical characteristics within salt particles?

What is its elemental, isotopic and structural makeup?

Approach: Graduate student Lucas Reynoso conducted several experiments to grow NaCl crystals under equilibrium conditions in a supersaturated solution of glycine. Crystals were then analyzed by a variety of techniques in order to quantify the intake of glycine via diffusion and inclusions in microporosity within the crystal.





Key Results for FY24:

A major result from this study is that the glycine uptake in the salt crystal is bounded. Figure 1 shows the glycine abundance in the salt crystals increasing with increasing concentration in solution. The relationship is linear, although error bars are large for lower concentrations.

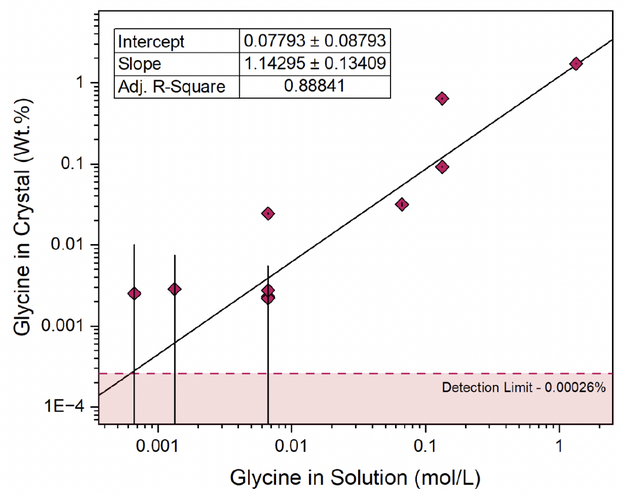


Figure 1, Glycine incorporated in halite crystal as a function of the concentration of glycine in solution measured at crystals grown in a few days.

After leaving the crystals to grow for weeks, the amount of glycine incorporated reaches a ceiling (Figure 2). This saturation is determined by the porosity of the crystals.

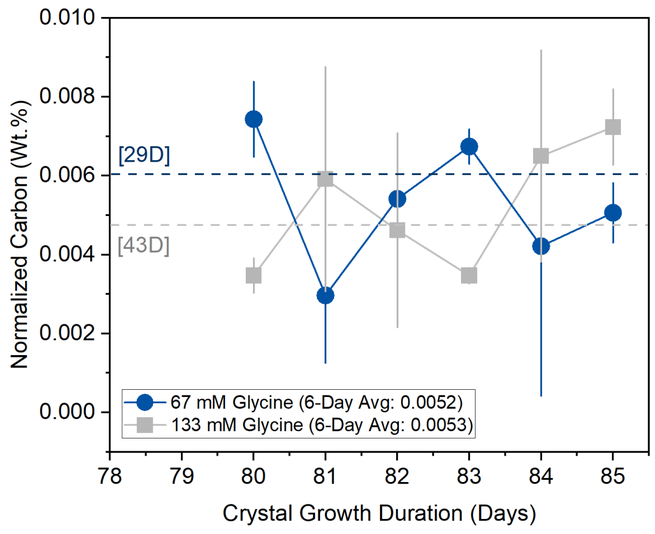


Figure 2. Carbon abundance (in wt.%) as a function of the time the crystal spent in solutions for two different glycine concentrations taken out at Day 29 and Day 43, respectively. Over nearly three months, the glycine uptake remained minimal and did not change with time. This suggests that the diffusion of ions in solution into the NaCl crystal does not occur.

In summary, NaCl can harbor organics and is unaffected by ionic or molecular diffusion into the crystal after they form during late-stage precipitation.

Significance/Benefits to JPL and NASA:

Extraterrestrial salts are rarely found within meteorites, because the salts easily degrade, while the meteorites are sitting on the Earth's surface. 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, in particular the Ceres Sample Return mission highlighted in the Origins, Worlds, and Life Decadal Report.

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

RPD-000 Clearance Number: CL#00-0000

Publications:

[A] Froh, V., Bose, M., Suttle, M. D., Nava, J., Folco, L., Williams, L. B., & Castillo-Rogez, J. (2023) Water-rich Ctype asteroids as early solar system carbonate factories. Icarus, 391, 115300. https://doi.org/10.1016/j.icarus.2022.115300

[B] Reynoso, L. R., Bose, M., Robinson, K. J., Root, R. A., Williams, L. B., Castillo-Rogez, J. C., Glycine incorporation in halite observed: Implications for a Ceres sample return mission. (In preparation).

PI/Task Mgr. Contact Information: Julie Castillo-Rogez
(818 640 9231, Julie.C.Castillo@jpl.nasa.gov