FY25 Strategic University Research Partnership (SURP)

Life Detection in Serpentinizing Systems Relevant to Current and Future Astrobiology Missions

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Objectives: The **primary objective** of this effort is to characterize the chemical composition of soluble organic matter present in environments where interactions between water and rocks can provide the chemical conditions for life to arise and persist. A **secondary objective** is to determine the most effective operations to successfully perform chemically-based life-detection analysis on a future spaceflight mission to an Ocean World.

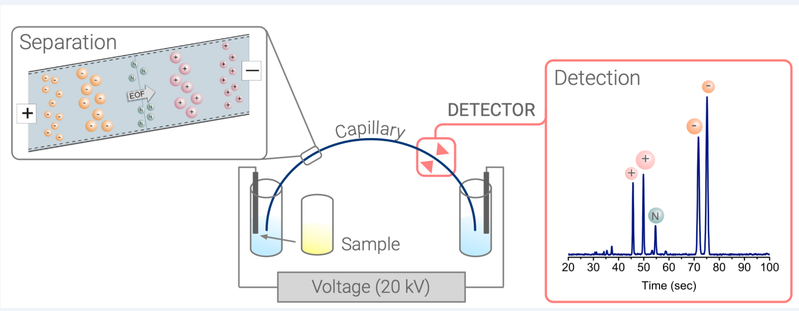
Our work focuses on analysis of samples from actively "**serpentinizing systems**", where ongoing water/rock reactions in olivine rich rocks fuel polyextremophilic microbial life sustained by the production of hydrogen and small molecular weight organic compounds. These processes are widely accepted to form the most likely basis for life expected on Europa, Enceladus and in parts of Mars shallow subsurface.

Background: Serpentinization is a ubiquitous process on rocky bodies with liquid water that can lead to the production of chemical energy sources, such as hydrogen and small organic compounds, that are essential for chemosynthetic life. It is known that serpentinizing systems on Earth can support an active chemosynthetic biosphere, intensifying the interest in missions to serpentinizing systems to other destinations in our Solar system. However, the distributions of biomolecules in these systems are not yet well characterized. Similarly, there are states in these environments with low biological activity where the chemistry is dominated by abiotic processes. Here we analyzed amino acids in highly serpentinized fluids from the Samail Ophiolite in Oman.

Approach and Results:

- We use the liquid-based separation technique capillary electrophoresis (CE). CE separations occur within glass capillaries (~50 µm ID) filled with an electrolyte solution. A small volume of sample (nL) is introduced into the capillary and voltage is applied between both ends. The applied voltage generates a bulk flow of the solution (EOF) inside the capillary and drives the separation of ions according to differences in mobility (Figure 2).
- For detection of trace amounts of amino acids CE is coupled to laser induced fluorescence (LIF) detection (Figure 3).

Figure 2. Diagram of a CE system indicating how ions of varying sizes and charges are separated.



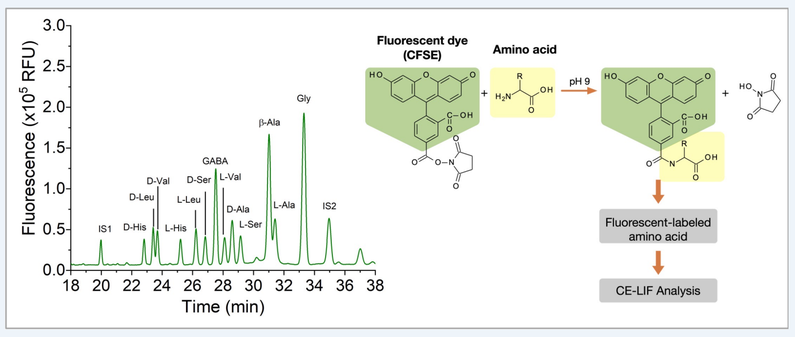


Figure 3. Left) Example of chiral separation of amino acids by CE-LIF. Right) Schematic of the reaction between 5-carboxyfluorescein succinimidyl ester (CFSE) and amino acids used to fluorescently label the amino acids prior to CE-LIF.

- Graduate student Ruth Quispe-Pisco analyzed samples with varying chemical properties from actively serpentinizing rocks in the Samail Ophiolite in Oman (Table 1).

Table 1. Properties of the samples analyzed during this project. Cell shaded green represent samples from 2025. Other samples were collected in 2023.

Borehole	Description	Depth (m)	pH	EC (µS/cm)
BA1B	Mildly Alkaline	20	7.8	498
		150	8.9	368
		250	8.1	491
BA1D	Moderately Alkaline	120	9.7	506
		250	9.7	520
BA4A	Moderately Alkaline	20	9.2	491
		150	9.9	604
		270	9.5	507
		300	10.6	50-2000
BA3A	Hyperalkaline	20	10.3	1439
		50	11.2	2710
		150	11.4	2960
		150	11.0	3132
		270	11.7	3330
Spike	Moderately Alkaline	50	10.7	49100
		100	10.8	50220

Samples were evaporated to remove ammonia and to preconcentrate amino acids (Figure 4). Data is still being analyzed but low levels of amino acids were detected in all the samples (low nM or ppt). Samples from the Spike borehole had a much higher concentration of amino acids and require dilution for analysis instead of preconcentration (Figure 5). This result is very intriguing because these samples also have much higher salinity.

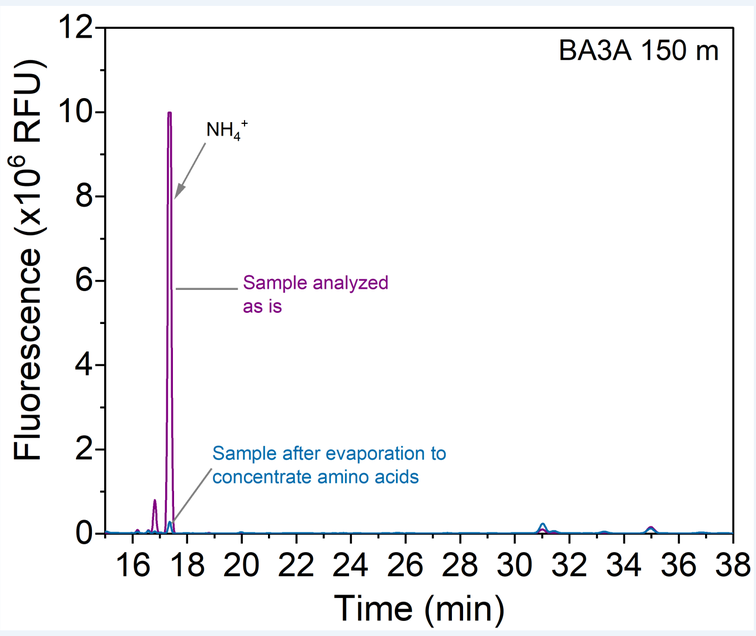


Figure 4. Electropherogram of sample BA3A 150 m analyzed before and after preconcentration indicating the peak corresponding to ammonia that is not present after the sample is concentrated.

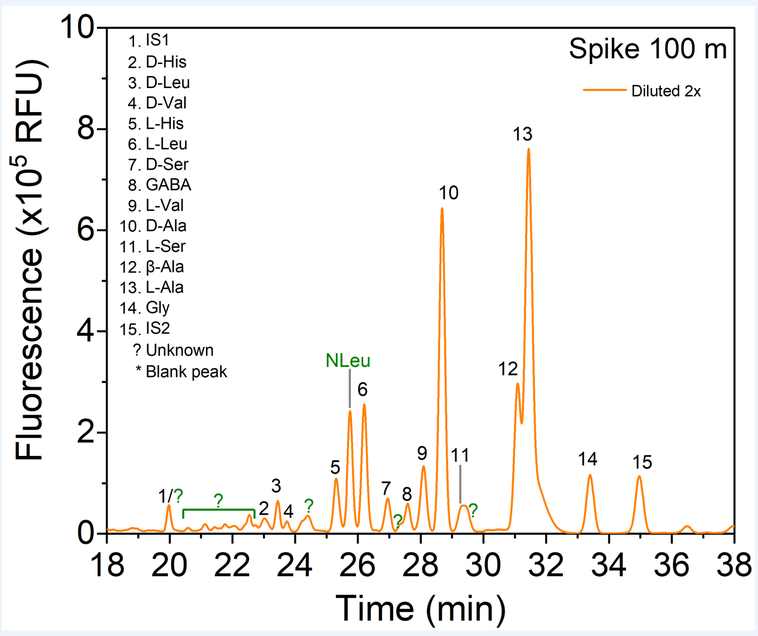


Figure 5. Electropherogram of sample Spike 100 m indicating the amino acids detected as well as some unidentified peaks. Internal standards are1 nM fluorescein (IS1) and 50 nM taurine (IS2).

Significance/Benefits to JPL and NASA: JPL has invested significantly in instrumentation for in situ chemical analysis that could be key on future life detection missions to Ocean Worlds. The results from this project will inform the implementation of this technology during future missions to allow the identification of biosignatures. Outcomes from this work would also contribute to understanding extreme environments on Earth as well as data from future missions.

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