DETERMINING HABITABILITY OF ICY WORLD OCEANS VIA ANALYSIS OF PLUME PARTICLES

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Introduction: The goal of the 2007 Phoenix Mars Lander *Wet Chemistry Laboratory* (WCL) was to analyze the aqueous geochemistry of the soils in order to better understand the history of the water, biohabitability of the soil, availability of chemical energy sources, and the general geochemistry of the site. The results of the Phoenix WCL analyses [1-4] clearly showed that a fundamental understanding of the present habitability of any planetary body cannot be adequately made without direct knowledge of its aqueous geochemistry. By identifying a concentration of high perchlorate (ClO_4^-) in the soil WCL helped explain the inability of several Mars missions to detect organics in the martian regolith, and generated a variety of hypotheses with implications for its geochemistry, habitability, and potential for supporting microbial life [5-6].

Determining the composition and properties of soluble species entrapped in the plume ejecta on Europa and Enceladus is equivalent to the initial mineralogy studies that were performed on the surface materials of Mars. Evidence that these icy moons possess a subsurface liquid ocean in contact with a rocky core [7], directly impacts the hypothesis that they may be habitable and may support life [8]. Dissolved salts as measured by WCL provide the strongest evidence for the types of water-rock interactions that are frequently invoked as necessary for habitability, and thus crucial for providing context for molecular biosignatures.

Though the subsurface oceans are likely hundreds of kilometers below the surface, determining the nature of these habitats can be accomplishable by analyzing the ejected material. The plumes of Enceladus are especially tempting because they are reasonably accessible and regularly occur [9]. Just as WCL determined bulk and trace ions in the leached martian soil, we have developed a flow through *microfluidic WCL* (mWCL), shown in Figure 1, that is capable of determining similar species and properties of ejected plume particles. Finding that subsurface oceans on Enceladus or Europa contain habitable environments would be of major scientific significance, regardless of whether or not life was detected.

Methodology: Using the TRL9 heritage of the flight-proven WCL *ion selective electrode* (ISE) sensors, mWCL will be able to characterize the aqueous chemistry of icy moon targets by determining the presence and concentrations of soluble components such as; Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, Br^-, NH_4^+, SO_4^{2-}, NO_3^-, CO_2 (g) and O_2 (g) and other dissolved gases, and chemical properties including pH, reduction-oxidation potential, alkalinity, and conductivity. The greatest challenge will performing such analyses with the limited sample available from the plume. Based on Cassini plume composition data [9,10], an educated estimate of the sample collected from the icy particle plumes of Enceladus by a reasonably sized collector with multiple flybys would be in the order of 50-100 µg. The mWCL must thus be able to analyze microliter-sized liquid samples.

To allow for µL-volume samples, the prototype mWCL has been designed to hold 14 sensors with a channel size that currently allows it to analyze a 100 µL sample. Thus the mWCL requires 10^4 times less sample than did the Phoenix WCL.

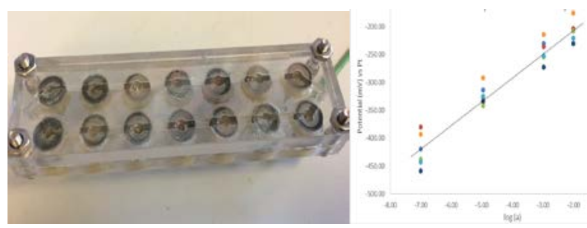

Figure 1: Response of six Na-ISE sensors using 100 µL volume prototype flow through sensor array.

Results: The main areas of investigation have focused on designing and demonstrating the prototype microfluidic WCL that can operate with a sample volume of 100 µL and demonstrating that the Phoenix WCL sensors in this microfluidic flow through configuration respond as those that operated on the Phoenix-WCL. Our initial results show that the ISE sensors not only respond as expected but they do so with better limits of detection than the WCL sensors. The results of our most recent experiments will be presented.

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