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ASSESSING THE HABITABILITY OF ICY OCEAN WORLDS.

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Presenter Biography: Sam Kounaves is a professor at Tufts University and a visiting professor at Imperial College London. He was lead scientist for the Phoenix Mars lander wet chemistry laboratory (WCL). His research is aimed at unraveling fundamental questions in planetary science using modern *in-situ* analytical systems designed to analyze and study the biogeochemistry in these extreme remote environments.

Introduction: The Phoenix Lander descended onto the surface of Mars carrying four identical *Wet Chemistry Laboratory* (WCL) units (Figure 1). The goal of the Phoenix WCL was to analyze the aqueous geochemistry of the regolith in order to better understand the history of the water, biohabitability, available chemical energy sources, and the general geochemistry of the site. The WCL successfully performed all its tasks and provided the first direct wet chemical analysis of soil on another planet [1-3]. The power of wet chemical analysis to change how we view the martian surface chemistry clearly demonstrated that a fundamental understanding of the present habitability of any planetary body cannot be adequately made without direct knowledge of the aqueous chemistry of the regolith and its aqueous geochemistry.

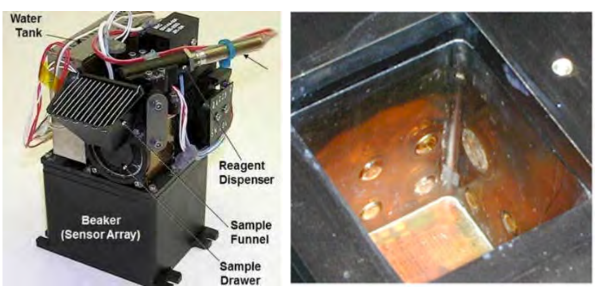

Figure 1. The flight-proven Phoenix Wet Chemistry Laboratory (WCL) and a view of its sensor array.

Determining the chemical composition and properties of the soluble species entrapped in the plume ejecta or surface coverage on icy worlds is fundamental science equivalent to the initial mineralogy studies that were accomplished on the surface materials of Mars. Although the icy moon oceans are likely 20-40 km below the surface, determining the chemistry of these subsurface environments can be accomplished by analyzing the materials that are brought to the surface. The plumes of Enceladus are especially tempting because they have been shown to erupt regularly, and that the silica particles found in the plume imply subsurface hydrothermal activity [4]. On Europa this is made possible by what appears to be a highly active ice shell [5], and more recently observed potential plumes [6].

The Microfluidic-WCL: Just as the WCL determined both bulk and trace soluble cations and anions in the leached martian regolith, the *microfluidic-based WCL* (mWCL), shown in Figure 2, will determine similar species and properties of the material ejected in the plumes or on the surface of the icy moons. During the past two years, supported by NASA COLDTech and ICEE2 grants, we have designed, fabricated, and characterized this prototype device. Based on the Phoenix WCL, it has been redesigned to fit into a small-form factor, operate with milliliter or microliter volumes, and withstand the temperatures and radiation that would be encountered during a 5-10 year cruise to an icy world. Throughout the redesign a prime goal was to ensure that the mWCL would be able to use the flight-tested heritage WCL sensors.

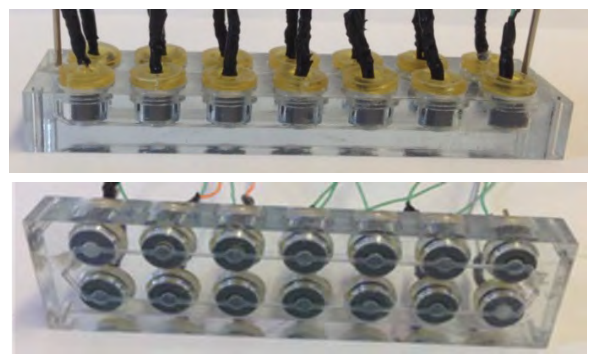

Figure 2. The microfluidic-WCL containing 14 ISE sensors interconnected by a sub-mm flow channel requiring only 100 µL of sample solution.

Results: The mWCL sensor array exhibited an order of magnitude improved LOD compared to the WCL, and responded faster and with improved sensitivity using a 100 µL volume. Interference tests using an Enceladus plume simulant showed the mWCL sensor array employing chemometric and AI algorithms can detect a variety of anions and cations in the presence of chloride levels expected in Enceladus' plume.

References:

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