POLAR MARS BIOHABITABILITY ASSESSMENT OF THE WET CHEMISTRY ANALYSIS ON THE 2007 PHOENIX MARS SCOUT MISSION. S.M.M.Young[1], C. R. Stoker[2], M. H. Hecht[3], [1]Department of Chemistry,Tufts University, 62 Talbot Avenue, Medford, MA 02155 USA; suzanne.young@tufts.edu, [2]NASA Ames Research Center, Moffet Field, CA 94035, [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Introduction: The 2007 Phoenix Mars Scout lander launched on 4 August 2007 and landed on 25 May 2009 at the northern polar latitude of 68.22°N, and longitude 234.25°E (areocentric) [1]. The landing site was a field of sand wedge polygonal terrain [2,3]. For 152 sols the mission made extensive atmospheric and ground measurements. Analyses included interacting with and excavating the Mars regolith with a robotic arm and delivering samples to payload instruments including microscopes (optical and atomic force), a scanning calorimeter-mass spectrometer (TEGA) and an electrochemical analyzer, (WCL). The work reported here addresses the implications of the Phoenix observations (reported elsewhere) for the prospects of Mars biohability.

The Wet Chemistry Lab: One instrument used to understand the chemical record was the *Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) Wet Chemistry Laboratory (WCL*) [4]. It includes four single-use independent cells, each composed of an upper assembly consisting of a reservoir of leaching solution (water and the first calibrants for the sensors), a 1cc sample drawer, and a reagent dispenser with crucibles containing, in solid form: a second calibrant, an acid, and barium chloride for determination of sulfate (Fig. 1). The lower WCL assembly consists of an array of electrochemically-based sensors for measuring pH, Eh, conductivity, cyclic voltammetry, chronopotentiometry, and dissolved ionic species via ion selective electrodes (ISE) for Na^+, K^+ , Mg^{2+}, Ca^{2+} , Ba^{2+} , NH_4^+, Cl^-, Br^- , I^- , and NO_3^-/ ClO_4^-.

The WCL experiment: During a MECA-WCL sol (a martian local solar day), the initial aqueous leaching solution containing 10^{-5} M Na^+, K^+ , Mg^{2+}, Ca^{2+} , Ba^{2+} , and NH_4^+ in the form of nitrate, bicarbonate, or chloride salts was delivered into the beaker of electrodes to pre-condition the ISEs and to provide a first calibration point. Next a second calibrant was added, bringing the concentration of the same salts to $3.4x10^{-5}$ M. WCL then received and analyzed a sample of Mars regolith from the robotic arm (Fig. 2). The sample was allowed to freeze for at least a sol. On the second WCL measurement sol, the acid was added, data was acquired, and the sulfate precipitation experiment with $BaCl_2$ was performed.

Relevant Mission Objectives: A major goal of the Phoenix mission is to address biohabitability by unraveling the history of Martian water, identifying potential chemical energy sources available to support life, and determining whether the subsurface geochemistry is hostile to life [1]. According to a report by the Mars Exploration Program Analysis Group (MEPAG), the potential for biohabitability is determined by four factors: (1) liquid water, (2) the presence of key elements (CHNOPS) that provide raw material to build cells, (3) bioavailable energy sources, and (4) the absence or protection from hazards [5].

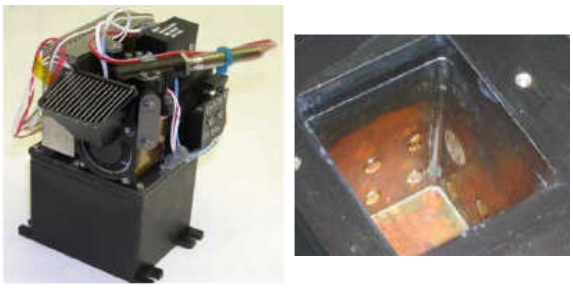

Fig. 1: Left: A WCL cell showing upper and lower assemblies. Right: The interior of the lower assembly, lined with ion selective electrodes.

WCL samples on Mars: Four WCL analyzers were present on Phoenix. The first analyzed a surface sample, Rosy Red. The second and fourth analyses were of scraped piles above the ice, Sorceress 1 and 2. The third was a subsurface sample, Golden Goose, but it did not drop through the screen protecting the WCL drawer because the regolith was very clumpy [2].

Relevant WCL discoveries: *Evidence for past liquid water:* The orbiters Odyssey, OMEGA, and MRO all detected the presence of water ice on Polar Mars [6,7,8]. The Robotic Arm Camera photographed two types of ice close up, and documented its sublimation once exposed. TEGA confirmed the presence of water ice in the regolith, not bound as a chemical ligand [9]. The salts found or confirmed by WCL offer possible evidence for the past presence of liquid water on Mars, including perchlorate anions, carbonate anions, and a suite of cations. A very high (~0.7%) concentration of the highly soluble anion perchlorate was found in all WCL samples [10]. Both TEGA and WCL identified another weakly soluble salt, $CaCO_3$ [9,11], which is responsible for the pH of 8.2 +/- 0.5 measured by WCL [11]. Dissolution of the ions was rapid, as would be the case if salts were dried upon the

surface of rock matrices, but may simply be indicative of the relatively small particle sizes in the matrix.

Bio-energy sources: WCL found high levels of ClO_4^- on Mars, a potential source of microbial energy [12]. It represents half of a red-ox couple and pairs easily with H_2 , H_2S, or Fe^{2+}.

Key bio-elements: Mineralogical carbon was found in the form of carbonate and minerological oxygen was found in the form of ClO_4^- , H_2O, and CO_3^-. Hydrogen is present in the form of water ice. Nutrient cations K^+ , Mg^{2+}, and Ca^{2+} were detected in all WCL samples. Analysis of the Ba titration for soluble sulfate is ongoing [c]. NO_3^- could not be detected because of its use as a counterion for cation calibration and because each sample contained ClO_4^-- for which the Hofmeister series sensor is most selective. PO_4^{3-} could not be detected by WCL. Other ions may have been present in an insoluble form.

Poisoning environment: None of the mineralogical substances found by Phoenix preclude habitability. Additionally, the determined pH of 8.2$\pm$0.5, close to that of Earth's oceans, is not extreme, nor in any way incompatible with microbial life.

Fig. 2: Phoenix image from the Surface Stereo Imager showing delivery of soil from the robotic arm to the WCL cell.

Conclusion: Several, but not all, of the crucial *chemical* factors for biohabitability were found by the WCL analyses on polar Mars regolith.

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References: [1] Smith et al (2009) *Science*, in press. [2] Arvidson et al (2009) *LPS LX* this volume. [3] Mellon et al (2008) *JGR*, 113, E00A23. [4] Kounaves S.P. et al. (2008), JGR, 113. [5] Mars Science Goals, Objectives, Investigations, and Priorities (2008), http://mepag.jpl.nasa.gov/reports/index.html [6] Boynton et al. (2002) *Science*, 297, 81-8. [7] Jouglet et all (2008) *JGR*, 112, E08S06. [8] Arvidson et al (2008) *JGR*, 113, E00A03. [9] Boynton et al (2009) *LPS LX* this volume. [10] Hecht et al (2009) *LPS LX* this volume. [11] Kounaves et all (2009) LPSC LX, this volume [12] Coates et all (2004) *Nature Review Microbiology*, 2, 569- 580.