

heating the samples to 1000C will performing differential scanning calorimetry on them. The gases are piped to a mass spectrometer and all species between 1 and 140 Da are identified. Altered minerals (clays, carbonates, etc.) and organics materials can be clearly identified by the multi-dimensional nature (mass, temperature, and depth) of this experiment. Isotopic ratios for hydrogen, neon, argon, carbon, and nitrogen will give clues to the history of the soils and ices. The MECA instrument performs microscopy, electro-chemistry, and conductivity measurements on samples. Bringing water from Earth and mixing it in a sealed cell with samples creates the same conditions as when the ice melts beneath the surface and allows us to determine the aqueous chemistry of the soils. Acidity, redox potential, and salt content are all acquired giving us the first idea of what the biological potential of this habitat might be. Microscopes examine the grain structures and the thermal and electrical conductivity of the soil is examined with a special probe on the scoop. A Canadian MET station uses a lidar to measure the depth of the boundary layer and also pressure and temperature throughout northern Summer and Fall. Phoenix provides insight into the biological potential of the near surface ice.

URL: <http://phoenix.lpl.arizona.edu>

P42C-06 1715h

Subsurface Halophilic Microbial Communities in the Hyperarid Core of the Atacama Desert: An Analog for Possible Subsurface Life in Regolith on Mars

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The Atacama Desert in its driest portion provides an interesting analog for possible past or present life in the Martian regolith. In the hyperarid core of the Atacama, surface soils are virtually abiotic, with no plants and "near sterile" concentrations of heterotrophic bacteria (i.e., exceedingly low densities of approximately 100 colony forming units per gram soil). The dearth of microbial life at the surface is likely maintained through extremely low water availability, low organic content and the highly oxidizing nature of the soil. In marked contrast to the surface, however, extremely halophilic microorganisms exist in salt layers 1.2-1.5m below the surface. Mineralogical analyses indicate the layers are predominantly halite (70% NaCl) but also contain sodium nitrate (5% NaNO₃). Culturing and polar lipid analyses suggest the halophiles are archaeal Halobacterium-like motile rods. Microclimate monitoring at 1m indicates a soil relative humidity of 20% which is stable year-round even during decadal rain events such as that experienced in July 2002. This suggests the layers are isolated from even significant moisture influxes at the surface. Although further research is necessary, important parallels exist between this Earthly desert analog and the possible existence and detection of subsurface life on Mars despite harsh abiotic conditions at the surface.

P42C-07 1730h

Sensitive Amino Acid Composition and Chirality Analysis in the Martian Regolith with a Microfabricated in situ Analyzer

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Recent advances in microfabricated "lab-on-a-chip" technologies have dramatically enhanced the capabilities of chemical and biochemical analyzers. The portability and sensitivity of these devices makes them ideal instruments for in situ chemical analysis on other planets. We have focused our initial studies on amino acid analysis because amino acids are more chemically resistant to decomposition than other biomolecules, and because amino acid chirality is a well-defined biomarker [1]. Previously, we developed a prototype electrophoresis chip, detection system and analysis method where the amino acids were labeled with fluorescein using FITC and then electrophoretically analyzed using cyclodextrin as the chiral resolution agent [2]. Extracts of the Murchison meteorite were analyzed, and the D/L ratios determined by microchip CE closely matched those from HPLC and GCMS and exhibited greater precision. Our microchip analyzer has now been further improved by establishing the capability of performing amino acid composition and chirality analyses using fluorescamine rather than FITC [3]. Fluorescamine is advantageous because it reacts more rapidly than FITC, and because excess reagent is hydrolyzed to a non-fluorescent product. Furthermore, the use of fluorescamine facilitates interfacing with the Mars Organic Detector (MOD) [4]. Fluorescamine-amino acids are separated using similar conditions as the FITC-aa, resulting in similar separation times and identical elution orders. Fluorescamine-aa are chirally resolved in the presence of hydroxy-propyl- β -cyclodextrin, and typical limits of detection are ~50 nM. This work establishes the feasibility of combining fluorescamine labeling of amino acids with microfabricated CE devices to develop low-volume, high-sensitivity apparatus for extraterrestrial exploration. The stage is now set for the development of the Mars Organic Analyzer (MOA), a portable analysis system for amino acid extraction and chiral analysis that will combine the capabilities of microchip CE with the previously developed extraction capabilities of MOD [4]. Amino acids are first extracted from soil by sublimation to a cold finger coated with fluorescamine for solid phase labeling. Sample transfer between MOD and the CE device is achieved through a capillary sipper driven by microfabricated valves and pumps [5]. The construction of a portable MOA instrument will facilitate in situ studies of amino acids in Mars analog sites such as the Atacama Desert in Chile. Preliminary chiral analyses of Atacama soil extracts on the microfabricated CE device have shown amino acid detection down to low ppb concentrations. Future field tests in the Atacama Desert will explore the feasibility of the portable CE device for performing in situ amino acid analysis. This work will provide the technology base for the development of the Mars Organic Laboratory (MOL), a portable device that will analyze a broad suite of biomolecules, including nucleobases, sugars, and organic acids and bases [6]. [1] J.L. Bada, G.D. McDonald, *Icarus* 114 (1995) 139. [2] L.D. Hutt, D.P. Glavin, J.L. Bada, R.A. Mathies, *Anal. Chem.* 71 (1999) 4000. [3] A.M. Skelley, R.A. Mathies, J. Chromatogr. A (2003) in press. [4] G. Kminek, J.L. Bada, O. Botta, D.P. Glavin, F. Grunthaner, *Planet. Space Sci.* 48 (2000) 1087. [5] W.H. Grover, A.M. Skelley, C.N. Liu, E.T. Lagally, R.A. Mathies, *Sens. Actuators B* 89 (2003) 325. [6] A.M. Skelley, F.J. Grunthaner, J.F. Bada, R.A. Mathies, in SPIE: Proceedings of the In-Situ Instrument Technologies Meeting, Pasadena, CA, 2002.

P42C-08 1745h

What are the best ways to look for extinct or extant life on mars? Thinking outside the box

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Although the Viking missions a quarter century ago performed a series of life detection experiments, the question of whether life ever existed or even still exists on Mars remains unanswered. The finding that the Martian surface is highly oxidizing seemed to preclude the presence of a robust surface biology, but the subsurface may be more compatible with respect to the survival of both viable organisms (1) and organic compounds. Moreover, it is now also known that the Viking GCMS would not have detected refractory organic compounds (2) or amino acids associated with over a million bacterial cells in a gram of soil (3). The entire Mars community now faces a major challenge as to what we should do next in our search for evidence of life on Mars. The option that is presently favored is to fly "safe" missions focused on characterizing the

mineral and elemental makeup of the surface with little emphasis on state-of-the-art analyses for important biomarkers. A second, or perhaps parallel, bolder approach would be to fly payloads made up of highly sensitive instruments designed to search for a wide variety of key organic compounds. Instrumentation available to detect trace levels of key biological compounds have improved dramatically since the Viking missions and many of these methods can be miniaturized so they can be accommodated into a spacecraft. The critical issue is what suite of instruments would provide the most definitive results in answering the life on Mars question. To rigorously address this question, we propose that various organic detection systems be extensively tested in situ using a common and well controlled set of samples in an environment that is known to have low levels of both microbes and organic compounds. One locality that would be a strong candidate is the Yungay Station site in the Atacama desert of Chile, one of the driest and harshest places on Earth. Only those instruments that are able to detect at high sensitivity organic biomarkers in a natural field situation such as this should be considered for components for a future Mars mission payload package. If an instrument can not detect the presence of life's organic signature here on Earth, there is no justification for flying this instrument in a payload to Mars! NIH and DOE embarked upon a similar critical competition to development the best methodology to sequence the human genome and this process was dramatically successful. NASA's search for possible signs of life on Mars deserves at the same level of critical and competitive decision-making where scientific capability rather than other factors determine what is included in payloads. 1. B. P. Weiss et al, *Proc. Natl Acad. Sci USA* 97, 1395 (2000). 2. S. A. Benner et al, *Proc. Natl Acad. Sci USA* 97, 2425 (2000). 3. D. P. Glavin et al, *Earth Planet. Sci. Lett.* 185, 1 (2001).

P51A MCC: 2002-2004 Friday 0800h

Sagan Lecture

P51A-01 0810h INVITED

Extrasolar Planets

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None of the roughly one hundred hundred extrasolar planets found to date closely resembles the Solar System. Unlike the Solar System, most extrasolar planets are in eccentric orbits. The giant planets in the Solar System all orbit beyond 5 AU, while the known extrasolar planets (with one exception) all orbit within 4 AU, with several in extraordinarily small orbits with periods of days to weeks. Current state-of-the-art technology can only detect giant planets, with the most massive planets being the easiest to detect. Nonetheless the planet mass function rises toward lower masses down to the limit of detection incompleteness, below a jupiter-mass. There are almost no planets more massive than 5 jupiter-masses though these would be the easiest to detect. The planet bearing stars are significantly enriched in elements heavier than hydrogen and helium relative to both the Sun and nearby stars. NASA, the European Space Agency, NSF, and the European Southern Observatory are all focused on "next generation" planet detection technologies including giant ground-based 30 and 100 meter telescopes capable of directly imaging giant planets, space-based interferometers capable of detecting terrestrial-size planets in earth-like orbits, and space-based telescopes capable of directly imaging earth-like planets and taking their spectra. The first of these next generation instruments should be operating by the end of the decade, with first results coming in around 2015. The goal of our group is to survey all Sun-like stars out to 50 parsecs, a total of about 2,000 stars. At the time of this writing (September 2003) we are surveying 1,700 of these stars using the Lick 3-m (California), Keck 10-m (Hawaii), 3.9-m AAT (Australia) and 6.5-m Magellan (Chile) telescopes. Recent discoveries from our group include several systems of multiple planets, the only known transit planet, and the first sub-saturn mass companions, as well as two-thirds of all known extrasolar planets. Solar System analogs, Jupiter and Saturn-like planets orbiting beyond 4 AU, have not yet been discovered. These elusive planets will begin emerging from our existing surveys before the end of this decade. By 2010 our surveys will provide a first planetary census of nearby stars, allowing us to estimate the ubiquity of planetary systems and of "Solar System" analogs, and thus put the Solar System in a Galactic perspective for the first time.

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