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Preface

Space Physics, Mars, and Life

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Guest Editors

THE ULTIMATE CHALLENGE of astrobiology today is to seek and find recognizable signs of life on solar system planets and moons, whose surface environments are generally hostile to the survival of life and its biosignatures. The controversial case in point is the Mars Viking Lander experience, which "produced ambiguous results that failed to establish the presence of life, identified unusual oxidative soil chemistry not anticipated during the experiment design, and left a lingering controversy over some of the results" (NRC-COEL, 2002). Future missions to icy worlds such as Europa, Enceladus, and Titan, all of which show the potential for either liquid water or prebiotic chemical precursors, will inescapably need to contend with the radiation products of space physics environment. Dusty Mars and icy Europa have in common the presence of abundant surface oxidants respectively produced, directly or indirectly, by irradiation. The dominant forms of life on Earth either produce or utilize molecular oxygen, and astronomical investigations for life on extrasolar planets will search for atmospheric oxygen in the form of ozone, another space irradiation product. Europa and Mars might conceivably have subsurface ecologies supported by naturally produced oxygen in different forms from the surface irradiation environment. The same radiation-induced chemistry produces oxygen radicals and peroxides that destroy exposed organic materials, so the oxidants are both potential blessings and curses for any life and associated signs of life in these environments.

The symposium entitled Space Physics, Mars, and Life at the Fall 2004 Meeting of the American Geophysical Union addressed a wide range of topics relating to interactions of the space environment with the Earth, the Moon, Mars, Europa, Titan, and comets. The present special collection of papers resulted from an open solicitation related to the symposium and comprises four works mainly focused on Mars and Europa but with broader potential applications to other similar surface and subsurface environments. The papers by Delory *et al*. (2006) and Atreya *et al*. (2006) develop the plasma physics and photochemical models for dust devil and dust storm production of hydrogen peroxide (H_2O_2) near the Mars surface. They derive production rates up to 200 times higher than would be expected alone from photochemistry in the atmosphere of Mars. Reported detection of atmospheric methane (Formisano *et al*., 2004; Krasnopolsky *et al*., 2004; Mumma *et al*., 2004) then suggests strong sources of geologic or biological origin since methane lifetimes would be short in an oxidizing surface environment.

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H_2O_2 is produced by energetic particle irradiation of water ice on the surface of Europa, as investigated in the laboratory experiments reported by Hudson and Moore (2006). These authors compare the remote spectral signatures of H_2O_2 and H_2O ices in the near-infrared region, and have found that H_2O_2 is more resistant to destruction by irradiation at temperatures of 80 K (which approaches that of Europa) than at the 20 K temperature of far more distant icy bodies in the outer solar system. Their finding—that H_2O_2 surface abundances are indicative of highly irradiated ices—leads to the fourth paper of Hand *et al*. (2006) on trapping of O_2, SO_2, and CO_2 in pure and mixed gas clathrates within the ice crust of Europa. The relatively lower density of pure O_2 clathrate could lead to oxidant saturation of the ice crust, while denser mixed gas clathrates carry O_2 to the bottom of Europa's putative subsurface ocean. Lower thermal and electric conductivities of the clathrates, as compared with water ice, could substantially modify the rheological and magnetic properties of the ice crust. On Europa and similar icy bodies, we are then free to imagine worlds in which ice crust geology and astrobiological potential are indirectly connected to the space environment through radiation-induced chemistry and oxidant production.

We thank the American Geophysical Union for supporting the Space Physics, Mars, and Life symposium and *Astrobiology* for publication of this first special collection of papers that connects space environment effects to astrobiology as part of a new focus topic, the Space Physics of Life, first addressed by Cooper (2003). Space Physics of Life is defined here as the astrobiologically relevant study of the interactions and relationships between potentially or previously inhabited bodies and the surrounding space environment. Understanding, mitigation, and even exploitation of space environment effects are needed for present and future missions to seek and find signs of life, organic and inorganic, beyond our home world.

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