WHY LIFE *SHOULD* HAVE STARTED ON MARS, AND SEARCHING FOR SURVIVORS IN SALTS. B. C. Clark[1] and V. M. Kolb[2], [1]Space Science Institute, 4750 Walnut St., Boulder, CO 80301, USA, bclark@spacescience.org, [2] University of Wisconsin-Parkside, Kenosha, WI 53141, USA, kolb@uwp.edu

Introduction: Mars should remain at the highest priority for future exploration for signs of life, compared to ocean worlds which are organic-rich but have offsetting issues. Furthermore, from several standpoints, Mars could be viewed as an even more favorable location for the origin of life than Earth itself.

Why Life *Should* have Started on Mars: The variety and favorability of settings on Mars is high. Compared to ocean worlds, having an atmosphere has many advantages. Sunlight provides a limitless supply of metabolic energy and O_2 genesis via photosynthesis.

Settings for the Origin of Life. Many different geologic settings have been favored for the prebiotic chemical evolution to produce the first life form. Suboceanic hydrothermal vents are one, but Earth's oceans are vast and the dilution effectively prevents the condensation reactions necessary to create the informational and enzymatic macromolecules that are key to life. Rather, wet/dry cycles (or, freeze/thaw) are favored, to promote polymerization.

Scenarios of hydrothermal activity on land (e.g., hot springs, mudpots, fumeroles, etc.) are more promising. Other favorable settings are ponds with organics from meteorites or comets. With a global-encircling ocean before the rise of continents, Earth may have been "too wet" for life to start. Mars putative "ocean" was small, and the ancient highlands were wet only when rivers, lakes, and/or groundwater were present.

Prebiotic Chemistry: Organics. Although the martian soil and sediments explored so far contain only miniscule amounts of organic compounds, the only successful explanation of the ancient greenhouse that allowed liquid H_2O on Mars is an atmosphere that contained not only the current CO_2 and N_2, but also H_2 and/or CH_4. Organics could have been produced by lightning or other energetic processes (cf. the Miller-Urey synthesis pathways). Mars is also closer to the asteroid belt, and hence had a higher probability of acquiring organics from suitable asteroids and comets.

Prebiotic Chemistry: Inorganics. Our Life requires the CHNOPS group of elements. Mars has been shown by various missions to have all these atoms in readily available form. However, certain other elements are also essential to life's enzymatic virtuosity, especially several of the transition metals, such as Fe, Mn, Ni, and Zn. In addition, some elements are involved in various prebiotic chemosynthetic pathways, including Cu for the Sutherland scheme of reactions [1] and boron for the Benner method of synthesis of RNA [2]. Zn, Ni, and Fe are ubiquitous on Mars, and recent discoveries have identified enrichments of Mn, B, and Cu. Redox-stratified lakes may have also been present [3].

Various minerals, especially clays, have been shown to have catalytic and other functions. Mars is abundantly endowed with deposits of smectite clays.

How it Could have Survived: If microbial life did start on Mars, has it survived?

Adapting to Adversity. As Mars lost much of its H_2O to become drier, those organism which could exist at low water activity (a_w) would prevail. As temperatures dropped and organic compounds were used up or destroyed by atmospheric photochemical processes, natural selection would favor organisms adapted to oligotrophic conditions and long periods of dormancy.

Quiescent Survival. Assuming eukaryotic protists and multicellular life did not evolve, or became extinct, the surviving microbiomes would be less exposed to predators. Periodic revival of robust endospores would occur during periods of higher temperatures caused by obliquity swings or the consequences of large impacts, such that portions of the large ice reservoirs are melted. This could enable extant life to persist to today.

Salt Deposits as Refugia. The martian surface is heavily endowed with soluble salts. Halophiles are abundant on Earth, and many organisms have been isolated which can flourish in $MgSO_4$ brines.

Searching for Survivors in Salts: The quest for evidence of biological activity should be re-introduced.

Biosignatures. Analysis of patterns in relative abundances of organic molecules may reveal life.

Probing for Metabolism. This could be done by stimulating uptake, conversion, and/or release of telltale molecules. However, it may be critical to provide the *suitable environment* needed to stimulate the organisms to become metabolically active. Temperature, pH, Eh, and a_w are some key parameters. Now that we realize sulfate is virtually everywhere on Mars, the presence of S-reducing chemoautotrophs utilizing H_2 could be tested. Ironically, just cm's from the Viking biology chambers was a tank of H_2 gas, inside the GCMS instrument. No cross-connection between instruments was available, however [4]. In the future, other redox couples could be tested.

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