DO MARTIAN BLUEBERRIES HAVE PITS?…ARTIFACTS OF MARTIAN WATER PAST

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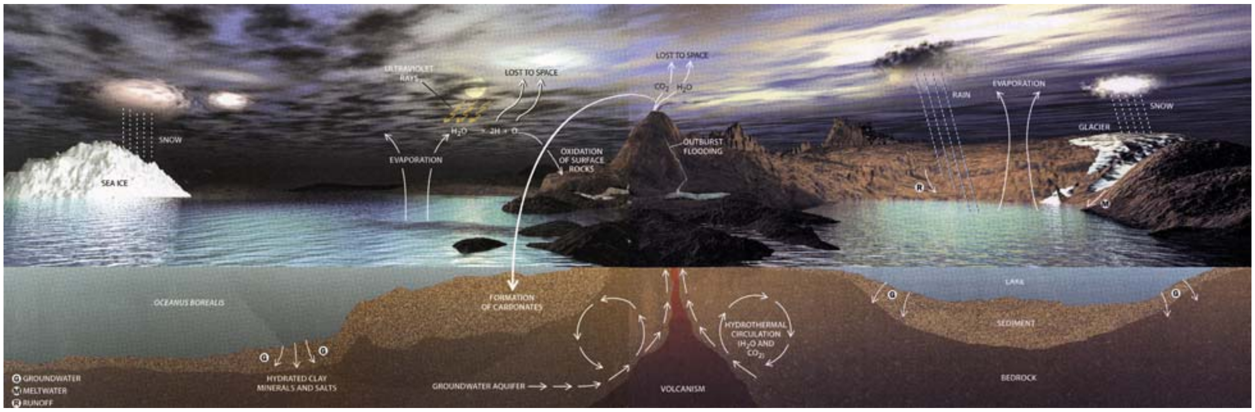

Figure 1: Possible Hydrological Cycles on an Early Wet Mars*

Introduction: The universalities of chemical physics offer considerable insights into the intimate details of hydrology cycles possible in Mars' past. Local 'organic weather cycles' inevitably form when the Rayleigh-Taylor instability in water is metastabilized by simple organic compounds, in turn leading to a complex set of mutually transforming phase transitions. In so doing these early Martian weather cycles would have also provided functional support for organic chemical self-organization, the assumed predecessor to an independent "origin" of Martian life. The existence of a significant subset of these cycles (both weather and organic self-organization) is likely even if surface waters were of such limited distribution as short time-scale lakes and intermittent turbulent flows. *One of a number of potential artifacts of these processes is the possibility that Martian blueberries have nucleated around organic cores, similar to the terrestrial concretions that appear to be their closest terrestrial analog.* Other important implications for Mars mission planning follow.

The capstone elements to all of this are the microenvironments that follow the existence of an air-water interface at a variety of physical scales: from the surface of a free-standing body of water (static or flowing) to white-cap induced bubbles and their aerosol progeny. Whether floating under water, bobbing at the sea-surface, or drifting in the atmosphere it is the adsorption of amphiphiles that drives these phenomena by decreasing the local surface energy; metastabilizing local fluctuations into micro-enviroments with organized structures capable of further organizing organics, metals, and larger scale particulates.

On the contemporary Earth this "bubble-aerosol-droplet" (bubblesol) cycle includes bubble formation and the adsorption of surface-active materials, bubble dissolution, and the non-equilibrium dynamics of bubble bursting. This leads to the formation of aerosols and their subsequent roles in atmospheric condensation. 'Membrane-like' phase boundaries are created at each node of this cycle, selectively concentrating organics and metal ions. Overall, this cycle provides an infrastructure for the concentration and transport of organic compounds, metal ions, and mineral catalysts through rapid sequencing hydration-dehydration reactions.

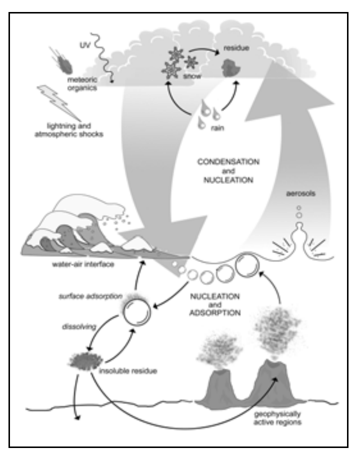

Figure 2: The Bubble-Aerosol-Droplet Cycle

On the early Earth this geophysical-chemical 'supercycle' is likely to have played a critical role in prebiotic chemical self-organization; for on the contemporary Earth bubble generated aerosols and their atmospheric progeny are the *largest transporters* of organic matter between the atmosphere and ocean, in both particle number and total mass. Additionally, the bubblesol cycle generates the principle nodes of heterogeneous organometallic chemistry in these regimes.

There is no reason to believe that this was not similarly the case on an earlier and wetter Mars. Specifically, on the tectonically simple early Mars (one having liquid water intermittently on its surface), such a complex hydrology cycle may well have been the only initiator and supporter of the rapid cycles of concentration, hydration, and dehydration necessary for organic polymerization in 'bulk' quantities.

With respect to an early Mars, the following more general conclusions seem warranted:

1) The finding of bubblesol-generated organic objects on Mars is prima facie evidence for the existence of a complex Martian hydrology cycle (capable of gathering, concentrating, and transporting organics).

2) *One of the more intriguing terrestrial analogues which may follow the creation of such organo-metallic entities is the possibility that the blueberries found by the Mars Rover team are similar to terrestrial concretions which are almost all nucleated around an organic/biological residue core.*

3) The presence of such bubblesol objects in (or from) an extraterrestrial location would demonstrate that environmental opportunities existed capable of supporting of prebiotic chemical evolution.

4) Natural consequences of the terrestrial bubble-aerosol-droplet cycle are objects with properties fascinatingly akin to those of 'nanobacteria': in particular the basic morphology (spheres and sausages), gross chemistry (suites of organics along with metals), and size distributions (nanometers to microns). Whether of biological or bubblesol origin, these striking similarities reflect the universality of the chemical physics involved in the interactions of charge-polarized organic amphiphiles at an air-water interface. Any life-searching Mars missions (or interpretations of Martian objects having made their way to Earth) must discriminate between the fossils of living systems at the micro/nano-bacterial scale and potential artifacts of the bubble-aerosol cycle necessarily found on any planet or satellite having both water and amphiphiles.

5) Additionally, IF bacteria (with surface active membrane elements) have existed on Mars, and were in any way tied to a surface liquid water environment, then these same bubblesol processes could have been a prime mode of concentration and aerial transport. In analogy to current terrestrial processes the larger of these bubblesol-generated objects (in their hydrated state) could easily have transported such bacteria across a mostly arid planetary surface. This would have been useful for 'colonization', and could also explain the deposition and subsequent fossilization of "micro-clumps" of such bacteria in environments much removed from their origin. The local geology of such exciting finds may thus be unrelated to the micro-environments of their origin and transport.

Further discussion of the bubble-aerosol-droplet cycle in supporting prebiotic chemical evolution on early Mars will be found in the author's accompanying paper at this conference, *"Could Martian Strawberries Be? — Prebiotic Chemical Evolution on An Early Mars"*.

[1] Lerman, L. and Teng, J. (2004) *Origins: Genesis, Evolution, and Biodiversity of Life* (ed. J. Seckbach) [2] Lerman, L. (2002a,b) *Origins of Life* 32, p. 419, 538 [3] Lerman, L. (1996) *Origins of Life* 26, p. 369 [4] Lerman, L. (1994) *Origins of Life* 24, p. 111, 138 [5] Chang, S. (1993) *The Chemistry of Life's Origins* (ed. J.M. Greenberg) [6] Lerman, L. (1992) *The Role of the Air-Water Interface in Prebiotic Chemistry* Thesis, Stanford University

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