WATER ON MARS AND THE VIKING BIOLOGY EXPERIMENT

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Since determinations (1-3) made in the 1960's indicated water vapor on Mars to average less than 50 precipitable microns, it has been apparent that the key to the state of chemical and biological evolution on Mars was the availability of liquid water. Mariner 9 photographs suggested (4) that there had been large flowing quantities of liquid water on Mars. Liquid water, thus, may have been available for evolutionary processes. Any life forms now surviving would have had to adapt to the present dry environment in which atmospheric conditions are so close to the triple point of water that it is uncertain as to whether liquid water exists even transitorily at the surface.

The landing sites for the Viking spacecraft were selected to maximize the availability of water, and the specific sampling spots at each lander were chosen upon visual examination to pick apparent former water channels and a possible "caliche" residue. The Viking life detection experiments were selected to expose Mars surface material to water environments ranging from dry to humid to moist to full immersion in liquid water.

The Pyrolytic Release (PR) experiment (5) established that the Martian surface material. when exposed to simulated sunlight in ambient Martian atmosphere, in the absence of added water or water vapor, converted CO_2 and/or CO into organic matter. The prospect that this was a biological response was enhanced by a control experiment in which a duplicate portion of the test material heated to 160ºC for three hours did not produce organics. An attempt to repeat the positive response produced a "marginal" result, but the PR experimenters believe this may have been caused by inadvertent heating of the sample to several degrees above the temperature of the first with the possibility that excessive drying occurred.

The Gas Exchange (GEx) experiment (5) has demonstrated that, upon the introduction of water vapor alone, Martian surface material reacts chemically or physically to evolve O_2.

The Labeled Release (LR) experiment (5, 6), that of the authors, has, in three active tests at two landing sites, evolved substantial quantities of radioactive gas upon moistening 0.5 cc of surface material with 0.115 ml of an aqueous solution of simple, ^{14}C labeled organic compounds. When the surface sample was heated at 160ºC for three hours prior to testing, a negative response tended to confirm the possible biological nature of the positives.

Although key biological criteria have been met by the PR and LR experiments, important confirmatory findings have not yet been made: (a) reproducibility of the PR positive, (b) kinetic evidence of growth in LR, and (c) detection of organics in Mars surface material by the Molecular Analysis (MA) experiment (7). Continuing Viking experiments will provide opportunities for such confirmations.

Inorganic reactions have been advanced to account for all of the observed phenomenon. The principal theory centers about the UV production of strong oxidants from monomolecular, adsorbed water on minerals. Attending free radicals or intermediates may reduce ^{14}CO or $^{14}CO_2$ to organic compounds in the PR chamber; the oxidants could decarboxylate one or more labeled compounds in the LR nutrient, and water vapor could provide a solvent for the decomposition of, say, H_2O_2, in the GEx instrument to release O_2. The fact that GEx saw less O_2 evolved at Lander 2 site than at Lander 1 site may support the latter reaction in that the average atmospheric water vapor content at site 1 was 8 precipitable microns compared to 25 precipitable microns at site 2 (8). Thus, the surface equilibrium at site 2 would be shifted away from the oxidant. However, the LR response was 30 percent stronger at site 2 than at site 1. This strongly implies that more than one reaction is needed to account for the LR and GEx results. It is hoped that the question of biology or chemistry will be resolved by the remaining Viking experiments and by current laboratory simulation studies.

Two additional notes on Mars water are relevant. The MA experiment, in heating its samples to drive any organics into its analysis train, found (6) the surface material to contain 0.1 - 1% water, apparently present as a stable hydrate. Finally, it has now been established (9) that the residual north polar cap is H_2O ice indicating that water permafrost must abound in vast regions of Mars. Thus, water vapor is provided to the Mars surface by seasonally melting and/or subliming ice, and, at the alternate season, by condensing atmospheric water vapor. These seasonal effects are modulated diurnally as is evidenced by low-lying ground fogs or clouds (9).

The continual bathing of surface material in a flux of water vapor, and perhaps, occasional, transitory liquid water, might be sufficient to maintain adapted biota. On the other hand, if the chemical theory prevails, this amount of water is apparently insufficient to permit the UV-produced oxidants to react to completion.

In surprisingly forthright fashion, the Viking biology experiments have confirmed the dominance and quantitative criticality of water in the unexpectedly strong chemical and/or biological processes evolved or evolving on Mars.

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