Odyssey gives evidence for liquid water on Mars

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ABSTRACT

Recent Odyssey data indicate water ice within centimeters of the Martian surface over wide latitudes. A significant finding in itself, this has much broader applications. This paper cites water phase physics with respect to the Odyssey data and Viking and Pathfinder data to make a case for the availability of liquid water at the planet's surface. Liquid water, possibly in biologically significant quantities, is predicted at least diurnally over broad reaches of Mars, including the two Viking landing sites where the Labeled Release (LR) life detection experiment obtained positive signals. Moreover, the data argue strongly against any putative oxidant in the Martian soil that many have assumed was responsible for the LR positive responses. The Odyssey data lend further strength to the author's claim that the 1976 Viking LR results are of biological origin, and warrant his proposal to send a chiral LR experiment to Mars as an unambiguous way to end the controversy.

Keywords: Life on Mars, Odyssey mission, Viking mission, water on Mars, Labeled Release experiment

1. INTRODUCTION

In 1976, the LR on the Viking Mission performed experiments on the soil of Mars that satisfied the pre-mission criteria for the detection of microbial life[1],[2],[3]. However, the two other biological experiments, the Pyrolytic Release (PR)[4] experiment and the Gas Exchange (GEx)[5] experiment on Viking were negative, and, when no organic compounds were detected in the Martian soil by the Viking gas chromatograph mass-spectrometer (GCMS)[6], a biological explanation of the LR data was generally deemed a dim prospect. Soon after the LR data were received from Mars, it was proposed[7] that the surprising activity detected in the soil, and the equally surprising absence of organics therein, could be explained by hydrogen peroxide photochemically forming in the Martian upper atmosphere. According to this theory, the peroxide rained down onto the surface, where it became part of the soil samples tested. The evidence on which the theory was based was the brief burst of oxygen that had evolved from Martian soil when it was exposed to water vapor in the GEx experiment. This oxygen was attributed to the destructive reaction of water vapor with the hydrogen peroxide in the soil. It was also presumed that the peroxide had oxidized one or more of the LR substrates, releasing the ^{14}C−labeled gas detected by the LR, thereby creating a false positive in the biology experiment.

However, years of laboratory work by many researchers failed to duplicate all aspects of the Mars LR data by non-biological means[8],[9]. A direct comparison[10] between the GCMS and the LR found that the LR detected cells in an Antarctic soil reported by the GCMS to be free of organic matter. An explanation has been offered[11] for the failure of the Viking GCMS to detect any organic matter in the Martian soil: a 10^6 advantage in sensitivity of the LR over the GCMS makes it possible that the GCMS could not sense the small amount of organic matter associated with the low numbers of cells (~50) demonstrated to be detectable by the LR. Further evidence of organics on Mars was supplied by analyses of meteorites attributed to Martian surface or near-surface origins[12],[13],[14] that found organic matter in them. A recent research effort[15] quantified the detection of microorganisms by the GCMS. Sterilized Mars analogue soils were inoculated with measured quantities of live *E. coli*. Sealed under Martian ambient pressure, the samples were then pyrolyzed at Viking GCMS conditions: 500º C for 30 seconds. Analysis of the resultant vapors showed that as many as 3×10^9 organisms per gram of soil would have been undetectable by the Viking GCMS.

Since Viking, relevant discoveries have been made of organisms living under extreme environments. Many terrestrial microbial forms are now known that populate environmental extremes until recently thought inimical to life. The envelope of temperature, pressure, atmospheric composition, and salinity has been pushed to unanticipated regions[16],[17],[18],[19],[20] including the environment of Mars. These findings make it likely that Martian organisms could be well adapted to the current Martian conditions. They also raise the possibility that terrestrial microbes hitchhiking on a meteorite ejected to Mars or on a spacecraft could survive the trip, safely land on Mars, and populate wide areas of the planet[21].

Two sensitive spectroscopic searches[22],[23] found no trace of an oxidant in the Martian atmosphere. The Viking Magnetic Properties experiment reported results[24] consistent with its experimenter's pre-mission criterion[25] for a non-oxidizing surface. More recently, additional variations of the oxidant theory have been published proposing superoxide ions[26] and iron (VI)[27] as the oxidant responsible for the Mars LR results. However, each of these theories has also been found[28],[29] wanting, and a case has been made[30] against the possibility of an oxidizing environment on the surface of Mars.

The LR data have recently been re-examined from a new point of view[31]. The temperature-related fluctuations in the amount of radioactive gas in the test cell may indicate a possible circadian rhythm superimposed upon a metabolic response.

Over the last quarter century, an independent, overriding barrier to the existence of life at the Viking landing sites or anywhere on the surface of Mars has been the presumed absence of liquid water. However, after years of reinforcing the arid Mars declared by Horowitz[32], the extensive literature on the subject now includes several recent reports stating that Mars had significant liquid water in its geological past[33],[34] and may have surface water today[35]. One paper[36] states that films of liquid water may currently exist over wide areas of Mars.

Levin concluded[37], in 1997, that the Viking LR experiment had, indeed, detected microbial life in the soil of Mars. Still, after more than a quarter of a century, the issue remains, at best, highly controversial. In response to mounting interest in the subject, NASA has sponsored a website, http://wufs.wustl.edu/missions/vlander/lr.html, dedicated to supplying scientists with digitized data of all the Viking LR experiments at both landing sites.

2. ODYSSEY FINDINGS

Last year, scientists reported[38],[39],[40] that Odyssey's Neutron Spectrometer in orbit around Mars had found hydrogen enrichment over wide areas of the planet's south polar, mid-latitude and equatorial regions ranging from the surface to one meter deep, its penetration limit. The likely candidate proposed for this material was water ice, in amounts ranging up to 15 wt. percent of the surface material. The second cited reference states "… the stratification of H into layers with over a factor of ten difference in concentration seems hard to sustain unless a volatility comparable to that of ice is responsible." Odyssey findings[41] reported this year reveal the Mars north polar area to be even richer in hydrogen and of greater extent, including towards equatorial latitudes, than in the south polar and adjacent regions. Most recently, a July 24 news release[42] confirms and extends these findings, reporting up to 50 percent water by mass in polar regions and from two to ten percent closer to the equator.

Under the low Martian atmospheric pressure, any water ice so close to the planet's surface would be volatile, in turn being replenished from beneath. Moreover, Pathfinder found[43] diurnal surface temperatures to exceed 20º C. Where this occurs in regions with near-surface ice, the ice would turn to liquid as the temperature rose above 0º C, remaining so until boiling away at about 12º C under ambient atmospheric pressure. This is supported by the water phase model seen in Figure 1, and is consistent with a model[44] for liquid water on Mars. The model is illustrated by the cartoon in Figure 2. It shows how the melting of an ice cube under Martian atmospheric conditions produces a microenvironment adjacent to the cube where the equilibrium results in liquid water. Experimental evidence[45] under simulated Martian conditions supports this simple thermodynamic model. Presented concurrently with this paper is a report[46] providing a more detailed mathematic analysis explaining the existence of water in liquid phase under Martian surface conditions when and where the surface temperature exceeds 0°C. Surface temperatures above freezing were found at the Viking 1 landing site, and snow or frost was seen (Figure 3) at Viking site 2.

One reported[47] analysis of the Odyssey data, in conjunction with orbiter images, offers an interpretation of images of dark "dunes" seen on Mars in areas identified as hydrogen-rich, as evidence of current biological activity.

Figure 1. H_2O Phase Diagram Showing Range for Liquid Water on Mars

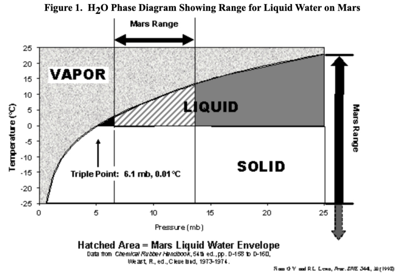
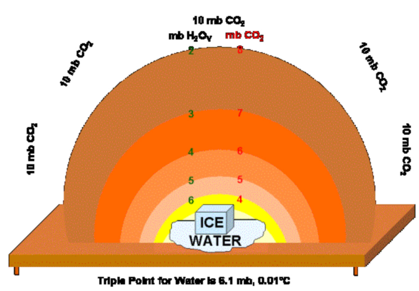


Figure 2: Melting, Evaporation and Diffusion of Water Under 10 mb CO_2



3. IMPLICATIONS

The Odyssey Neutron Spectrometer studies make a strong case for near-surface ice. Under prevailing Martian conditions of atmospheric pressure and topsoil temperature, liquid water would result from the equilibrium of the three phases of water, if only as moisture in the soil. As the temperature changes through the day, the liquid phase might last only hours, and that might depend on the location and season. However, when the surface temperature rises above freezing, and the atmosphere pressure remains above the triple point, the effusing water vapor will saturate the atmosphere immediately above, or adjacent to it, producing an equilibrium including the liquid phase.

Figure 4 shows the approximate locations of the two Viking landers superimposed on the epithermal neutron density map[48] generated by Odyssey. The Viking 1 landing site, 22.483º N, 47.82º W, is in an area reported to be slightly to moderately depleted in epithermal neutrons, registering approximately 7-8 epithermal neutrons per second as measured on the color bar

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If the putative oxidant were so labile to water vapor, as indicated by the sole "evidence" for it, the pulse of oxygen detected by GEx, the constant water vapor bath it would be subjected to in the upper Martian regolith makes survival of the oxidant difficult to explain. Were it to precipitate from the atmosphere daily, as some theories have proposed, the oxygen thus generated over geological eons would be expected to constitute more than the 0.13 percent of the Martian atmosphere as detected by Viking. If, on the other hand, the active agent in the Martian soil does <u>not</u> react with the water vapor that the Odyssey data would require to permeate the soil, <u>the evidence for its being an oxidant fails.</u>

4. CONCLUSION

The Odyssey findings seem to provide the liquid water necessary for life, including at the Viking sites where the LR experiments obtained strong positive results. In addition, they remove the oxidant inimical to life. Both results are compatible with and support the author's conclusion that the Viking LR detected living organisms in the soil of Mars. The proposed[50] return to Mars of the LR experiment modified to detect chiral specificity in the soil, a property shown by biology but not chemistry, could resolve the issue beyond reasonable doubt.

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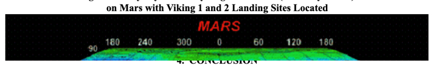
Figure 3. Heavy Frost, or Snow, Deposit at Viking Lander 2 Site (Viking Lander Image 211093)

Figure 4. Odyssey Plot of Hydrogen Densities (Probably Water) on Mars with Viking 1 and 2 Landing Sites Located



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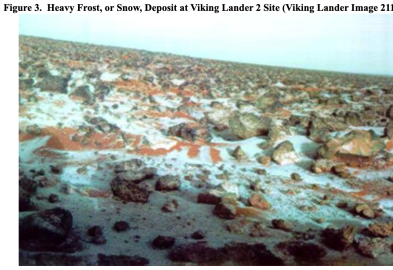

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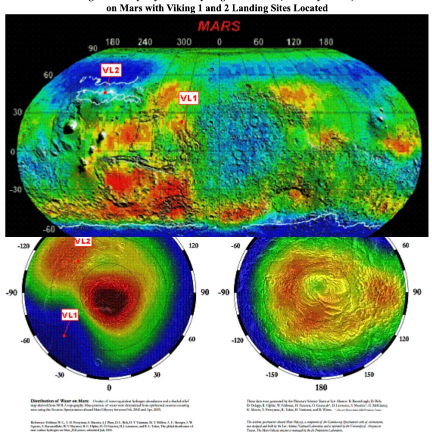

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