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CONDITIONS OF THE MARTIAN ATMOSPHERE AND SURFACE IN THE REMOTE PAST AND THEIR RELEVANCE TO THE QUESTION OF LIFE ON MARS, Kevin D. Pang and Fun-Dow Tsay, Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109

Although the Viking Landers failed to find any evidence of life on the surface of Mars, much remains unknown. Study of returned samples can answer some of these questions. The search for organic compounds, the building blocks of life forms based on carbon chemistry, should continue. Even a negative result from ultrasensitive laboratory analysis can tell us much about the present conditions and past environment on Mars. Laboratory analyses of lunar samples showed that 1.5 - 2% by weight of lunar soil is meteoritic material similar to C1 chondrites. The destruction of the infallen organics by photolysis appears to be incomplete, as simple organic molecules are present in the lunar samples (1). Since the energetic hard UV radiation required to photolyze organic molecules (2) is absorbed by Mars' $CO_2$ atmosphere the destruction of organics on Mars is believed to be by photocatalytic oxidation. The conditions required for such a process to take place appear to be present planetwide (3). The absence of organics under a rock (4) can be explained by the migration of free radicals from the surface, where they are created, into the interior, where they would react with any organic molecules present there. If this scenario is correct it is doubtful that endolithic life forms (5) can exist under the present Martian surface conditions. The Viking gas exchange experiment results point the way to where we should look in any future sample collection attempt.

When Mars soil was moistened $O_2$ and $CO_2$ were released. The reaction seems to be the displacement of bound oxygen by water (6). Thus, the presence of water appears to mitigate the harsh chemical environment, and the search for liquid water in pores or underground should have high priority. MECA studies suggest that a much wetter climate once prevailed on Mars (7). Close examination of river beds and "lake shores" and collection of samples from sediments could yield evidence of fossil life forms, as conditions for the origin and evolution of life appear to have been more favorable in the past not only because of wetter conditions, but a richer soil as well.

Plants readily grow on lunar soil samples when water and nutrients are added. Although Martian soil is now organic-poor the present condition may not be representative of what it was in the past. With a meteoritic infall rate three times greater than that of our Moon and assuming the same C1 chondritic composition, Martian soil should have been organically richer than lunar soil at one time (8). The infall of ancient satellites could have further enhanced the fertility of the Martian regolith. The high proportion of oblong craters on Mars is believed to have been created by grazing impacts of lost satellites. The total mass of infallen material has been estimated to be $\sim 10^{22}$ g (9). If the composition of this swarm of extinct moons is the same as that of the remnants - Phobos and Deimos (10) - a layer of organic - rich C1 chondritic material about 50 m thick would have covered Mars if spread around uniformly. The total mass of the lost satellites was most likely much greater, perhaps by more than an order of magnitude (9). Using the upper limit and assuming an average mixing depth of 1 km we estimate that the Martian regolith could have had a concentration of organic material as high as a few percent. It is interesting to speculate on what could have happened if water were added to such organically rich soil.

Some exobiologists believe that life originated on Earth with the help of $\sim 10^{23}$ g of cometary material (11); now known to be similar to ice and Cl chondrites from in situ measurements at Comets Halley and Giacobini Zinner. By comparison Mars also got at least an equal endowment of organic molecules, including complex amino acids. Over 99% of the ancient satellite mass impacted prior to the last episode of Martian volcanism less than 1.1 b.y. ago (9). Thus it appears that there was at least a time when an organically rich soil, thick atmosphere and running water coexisted on Mars. If life is spread by Pansperma conditions on Mars seem to have been favorable then. If life originates by chemical evolution, then whether it did or not depends critically on how long the paleoatmosphere stayed around to keep water from freezing on Mars. On Earth life originated only a few hundred million years after our planet accreted. If life had originated on Mars it should have invaded every niche as on Earth, including aquifers that may still exist under the now arid Martian surface (12).

In conclusion we emphasize that the question of life on Mars is still an open one, and deserves to be addressed to by the study of returned samples. Whether life developed and evolved on Mars or not depends critically on the history of the Martian atmosphere and hydrosphere. The exobiology of Mars is thus inextricably intertwined with the nature of its paleoatmosphere and the ancient state of the planet's regolith, which may still be preserved in the polar caps and underground. Core samples from such sites could answer some of our questions.

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