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*MICROENVIRONMENTS FOR LIFE ON MARS**

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The present capability for space flight gives timely urgency to discussions of problems of life on extraterrestrial bodies, especially Mars. Until the advent of these flights, there have been two approaches to the issue: the speculative construction of models of the environment and ecology of Mars, and direct telescopic searches for indications of life on that planet. These two approaches have pointed in opposite directions.

The low average temperatures, low mean water vapor content, absence of extensive bodies of pure liquid water, low atmospheric pressure, absence of molecular oxygen, and possible high ultraviolet radiation flux are undeniable constraints on Martian biology.[1–5] Some *terrestrial* microorganisms survive in purported simulations of the average Martian environment.[6, 7] Most would fare poorly, and whether any can proliferate in an accurately simulated environment is less clear. In any event, how well the *Martian* organisms have learned to cope with the same constraints remains to be seen.

The observational evidence falls into three categories: (1) seasonal and secular changes in the albedo, color, and delineation of the Martian dark areas,[2, 8, 9] (2) seasonal changes in the polarization of light reflected from the dark areas but not the bright areas, suggesting periodic changes in the size and distribution of small scattering granules on the Martian surface,[10] and (3) spectral features in the infrared reflection from the dark (but not the bright) areas which have been interpreted as absorption by CH and CHO.[11, 12] There are obvious difficulties in detecting extraterrestrial life over interplanetary distances and none of these observations can, by itself, be very convincing. Deliquescent salts might darken and change color upon wetting, as might the polarimetric properties of mineral granules. The infrared observations are evidence for carbonaceous matter on Mars, not necessarily of life.

Apart from these inconclusive observational arguments, how might we construct a model for a life-bearing Mars? We should take account of the severe constraints posed by the average environmental conditions, which have led some authors to reject the possibility of Martian life. An approach to this question has already been suggested.[13] The Martian environment is heterogeneous on a large scale both in space and in time. The surface temperature varies from <200K to 310K. The seasonal changes in the polar ice caps imply a variation in the availability of atmospheric water vapor. High resolution studies of the Martian topography show progressively finer and more variegated detail. We have much less insight into the small-scale variation of temperature and humidity to specify the microenvironments in which organisms might flourish.

The average microwave temperature of Mars, integrated over the whole disk, is 211 ± 28°K.[14] As this temperature refers to a depth of some decimeters, it is unlikely to undergo much diurnal or seasonal variation. The low abundance of water in the Mars atmosphere may be due to its condensation as permafrost at these low temperatures as well as to its escape from the atmosphere,[15] as has already been suggested for the moon.[16] The permafrost hypothesis lends special importance to the distribution of localized geothermal activity—hot springs, fumaroles, volcanoes. Such hot spots should be accompanied by local outgassing and by higher water vapor pressures in the overlying atmosphere, making these locales much more favorable microenvironments for life. Recurrent clouds at specific locales—often attributed to elevation differences—may be symptomatic of this local outgassing of water vapor. Once the permafrost has been broken through, a continued supply of moisture and heat should be available from deeper layers to maintain hot spots, the general circulation of gasses from the interior being impeded by the permafrost.

McLaughlin[17] has proposed that volcanism accounts for many of the major features of the Martian topography. His conclusions have been criticized[18–20] and defended[21] on various grounds. Our proposal should be distinguished by its stress on the significance of more localized geothermal activity such as fumaroles.

A search for favorable microhabitats can be made from planetary flyby vehicles such as the Mariner series.[22] Energy limitations have restricted the areal resolution of Earth-based spectroscopy and bolometry to >500 km; this should be improved by at least an order of magnitude by early missions. Do the areas where organic matter is concentrated also show the greatest seasonal changes? Are there any local concentrations of water vapor? Do anomalous warm spots persist, during the Martian night phase, which cannot be observed from Earth? Are these features correlated? If so, they will point to the most plausible sites for landing experiments carrying monitors more explicitly directed to the detection of biological activity. A continuing series of flyby vehicles capable of video reconnaissance, infrared spectrometry, and bolometry with progressively higher topographical resolution—hopefully down to a few hundred meters—would be of great value in directing our search for life on Mars.

Summary.—Deductions as to the habitability of Mars, of great importance in planning for space explorations, must take account of local variations, as well as the harsh, average features of the planet. For example, substantial moisture may be frozen in the subsoil, moisture and warmth being available through localized geothermal activity. Models of this kind pose specific questions for high-resolution reconnaissance in planetary flyby missions.

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*HIGH PRESSURE CHEMISTRY, I: ULTRA RAPID RATES AT VERY HIGH PRESSURES**

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Explosive shocks of about 300,000 atmospheres for 1 microsecond when applied to graphite containing about 20 per cent domains of the rhombohedral structure were shown by De Carli and Jamieson[1] to yield diamonds. They observed that the temperature and pressure during the shock are well within the region of diamond stability, but concluded that the 1 μsec of time available was unlikely to be adequate for a mechanism involving wide scale atomic movement and growth processes. They suggested that since rhombohedral graphite could by a simple com-