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HARVARD COLLEGE OBSERVATORY
CAMBRIDGE 38, MASSACHUSETTS

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Dr. Philip Abelson
Geophysics Laboratory
Carnegie Institution of Washington
Washington, D. C.

Dear Dr. Abelson:

Many thanks for letting me see a prepublication copy of your paper "Abiogenic Synthesis in the Martian Environment." Several of the points touched, such as the low mean water vapor abundance, and the high surface ultraviolet flux have been discussed many times before. Since reasonable physical mechanisms to protect hypothetical Martian organisms against these potential hazards can be envisioned easily, I do not see how they can be used as an argument against indigenous life on Mars. Your deduction that the Mariner IV observations exclude the presence of hot springs on Mars seems to me very dubious, considering the difficulties in interpretation of the Mariner IV pictures and because of the assumed terrestrial analogy.

ABELSON 1 P.

The main new point which you introduce is, I believe, the contention that Mars could, at any rate, have retained a reducing atmosphere only for very brief periods of time in its early history, and that the origin of life there is correspondingly unlikely. I believe the same argument implies that life on Earth is impossible. Rubey's discussion of excess volatiles in the Earth neglects the outgassing of hydrogen, because of its rapid escape from the Earth. Due to the high rate of escape of hydrogen from the base of the terrestrial exosphere, the net rate of escape of hydrogen from the Earth is governed not by the exospheric temperature but by the supply rate to the base of the exosphere, which is in turn determined by the diffusion properties of the lower atmosphere. The net e-folding time for the escape of hydrogen

from the Earth's exosphere is $\sim$1000 years. If Chamberlain's estimate of the Martian exosphere temperature, $\sim 900^{\circ}K$, is valid, the e-folding time for the escape of hydrogen from Mars is of the same order of magnitude. In this case the actual hydrogen escape rate is not determined by the fraction of outward-directed molecules with velocities in excess of the escape velocity, but instead, as on Earth, is diffusion-limited. If the much lower temperatures implied by the Mariner IV occultation experiment are applicable to the Martian exosphere, hydrogen will have substantially more difficulty escaping from Mars than from Earth.

Thus, any argument which uses contemporary parameters for the escape processes and which purports to show that Mars could not retain a primitive reducing environment must also imply that the Earth could not have retained a primitive reducing environment, and that life never developed on this planet, contrary to the prevailing evidence. The existence of a primitive reducing terrestrial atmosphere for a significant period of time implies the existence of a similar atmosphere on Mars. This conclusion might be avoided if we were to assume much less outgassing of reduced compounds in early Martian history, but there is no compelling evidence for such a conclusion. In discussions of exospheric energy balance in primitive reducing atmospheres, it would be preferable to use, instead of contemporary parameters, the more germane primitive values. Unfortunately, the theory required to compute exospheric temperatures in reducing atmospheres is in an extremely primitive state. I am enclosing a related discussion of atmospheric evolution for your comments.

Sincerely,

Carl Sagan

CS/ttb
Enclosure