ORGANIC DEGRADATION UNDER SIMULATED MARTIAN CONDITIONS.

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Although the results of the Viking Lander surface experiments mimicked a biological response in some respects, it is widely held [1,2] that they were not produced biologically, but rather resulted from a highly reactive surface chemistry. One reason for this interpretation was the striking result of the Gas Chromatograph Mass Spectrometer (GCMS), which showed that the martian surface soils had no organic compounds, within the detection thresholds of the instrument. The reported presence of indigenous organic compounds, recently detected in the Mars meteorites EETA 79001 [3] and ALH 84001 [4] casts a new light on the null results from the Viking Lander experiments. Questions regarding organics near the martian surface may now be directed at the details of their fate and distribution, rather than their mysterious lack of existence. Meteoritic material is estimated to reach the martian surface at rates of between 2,700 and 202,200 metric tons per year [5], resulting in martian soil that is as much as 58% meteoritic debris. Furthermore, because of Mars' low gravity and atmospheric pressure, much of the meteoritic material may arrive unmelted. Since organic carbon should comprise up to 10% of meteoritic material deposited on Mars, lack of organics on Mars implies that an active mechanism for destroying them is present. Since organic carbon remained undetected, it must be concluded that it is being destroyed at rates greater than its influx. Organic compounds produced by biological activity, either life or the past remains of life, may be meeting a similar fate. The results of a large number of laboratory simulations of the Lander experiment data pointed to a highly reactive soil chemistry as the culprit. The existence of oxidants in the martian regolith was inferred from the results of the Viking Lander's biology experiment package, particularly the Labeled Release (LR) and Gas Exchange (GEX) experiments. The evolution of CO_2 from the LR experiment is consistent with the presence of a thermally labile oxidant such as H_2O_2 [1], which can act to destroy organics. The existence of alkali and alkaline earth superoxides [6] have been proposed to explain the evolution of O_2 in the Gas Exchange experiment (GEX), as well as to provide a destruction mechanism for organic compounds. However, alternative explanations for the dearth of organics found at the martian surface are possible. Photochemical processes alone may be responsible, independent of the presence or identity of oxidants. Understanding the rate at which organic compounds are destroyed photochemically on Mars is important for placing constraints on soil carbon chemistry.

We report on laboratory experiments which simulate the breakdown of organic compounds under martian surface conditions. Chambers containing Mars-analog soil mixed with the amino acid glycine were evacuated and filled to 100 mb pressure with a martian atmosphere gas mixture and then irradiated with a broad spectrum Xe lamp. In the UV and violet, the Xe lamp spectrum closely simulates radiation at the martian surface. Head space gases were periodically withdrawn and analyzed via gas chromatography for the presence of organic gases expected to be decomposition products of the glycine. The quantum efficiency for the decomposition of glycine by light at wavelengths from 2000 to 2400 Å was measured to be 1.46 ± 1.0 x 10^{-6} molecules/photon. Scaled to Mars, this represents an organic destruction rate of 2.24 ± 1.2 x 10^{-4} g of C m^{-2} yr^{-1}. Upper and lower bounds for the influx of meteoritic organic carbon are 5.2 x 10^{-5} g m^{-2} yr^{-1} and 6.9 x 10^{-7} g m^{-2} yr^{-1} [5]. Therefore, organic compounds are destroyed on Mars at rates far exceeding the rate that they are deposited by meteorites. Thus, the fact that no organic compounds were found on Mars by the Viking Lander Gas Chromatograph Mass Spectrometer experiment can be explained without invoking the presence of strong oxidants in the surface soils. The organic destruction rate may be considered as an upper bound for the globally averaged biomass production rate of extant organisms at the surface of Mars. This upper bound is comparable to the slow growing cryptoendolithic microbial communities found in dry Antarctica deserts. Local oases with higher biomass productivity could exist over very small areas, generating organics at a global rate undetectable by the Viking GCMS.

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