

NSG-101-61

5p.

(London),
Reprinted from Nature, Vol. 200, No. 4902, pp. 114-116,
October 12, 1963

114-116
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N 64 1 474 1

CODE NONE

EVIDENCE FOR LIFE ON MARS

By DR. [D. G. REA]

Space Sciences Laboratory, University of California, Berkeley 4

608009
California U,
Berkeley
Space
Sciences
Lab.

IN 1954, de Vaucouleurs¹ wrote, "As for the idea, so often expressed, of a different kind of life adapted to such conditions (that is, on Mars)—what might be termed a 'generalized life'—it remains to a large extent beyond the realm of positive science".

This approach does not seem to have had much appeal, and most authors since then have stressed the positive aspects, generally overlooking contradictory observations. Indeed, the reader would undoubtedly conclude that various observations of Mars indicate considerably better than an even chance for the existence of life there. My opinion is that the evidence has been distorted and that a re-examination is required. An examination of the scope necessary will not be undertaken here; rather only a few observations intended to illustrate this point will be presented.

The observational arguments for the existence of Martian life are: (1) the various colours, including green, exhibited by the dark areas; (2) the seasonal changes in the visual albedo and polarization of the dark areas; (3) the ability of the dark areas to regenerate after an extensive 'dust storm'; (4) the presence of 2,700-3,000 cm⁻¹ 'absorption' bands, attributed to organic molecules.

It has been shown recently that the last, most recent, point is at least doubtful². The argument on the basis of the colours is also inconclusive. Kuiper³ demonstrated the absence of the near infra-red reflexion maximum, characteristic of most green plants, indicating that chlorophyll was not responsible for the colour. In this context Sinton has noted that this does not exclude chlorophyll since there may be present other pigments absorbing the near infra-red radiation. This would actually be expected since any Martian plants would probably evolve into forms reflecting the barest minimum of the sparse solar radiation available. It has been suggested by many workers that the colour is a contrast effect with the bright reddish continents. The meagre quantitative data have been discussed by Öpik⁴, who has reduced photometric observations of Kozyrev on the very dark area Syrtis Major to intrinsic reflectivities by factoring out the estimated atmospheric attenuation and reflectivity.

The result is that this area is bluer than a continent, but its colour is still reddish. His reduction is question-

(NSA Grant NSG-101-61)

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able since he assumes the surface-scattering properties to be similar to the Moon in the sense that the disk would be uniformly bright if no atmosphere were present. In fact, quantitative studies by Dollfus⁵ show the surface to have reflecting properties in orange light intermediate between lunar and Lambert surfaces. However, the qualitative conclusion that Syrtis Major has a red tint seems reasonable. While these considerations all weigh against a chlorophyll-based plant life, the lichen systems suggested by Kuiper (but criticized by Salisbury) can satisfy the observed colours, real or imaginary. The broad-leaved plants envisaged by Salisbury must have a chemical composition completely unlike any such terrestrial species, but this is to be expected. The significant point is that there is no positive colorimetric evidence pointing to forms of vegetation with which we are familiar.

The second and third arguments remain the most cogent; but the second loses some of its allure when one considers the severity of the Martian climate. Focas⁶ has photometered several dark regions on Mars from plates taken over a Martian year. All reveal a seasonal change in the albedo with a distinct darkening wave moving from pole to pole with the seasons. An area showing one of the greatest seasonal changes is *Depressio Hellespontica*, located at about 60°–65° S. latitude. Now the temperature at this location, according to the data of Lampland as reduced by Gifford⁷, reaches a maximum of -23° C for the southern summer. This temperature has an uncertainty due, among other factors, to the assumptions that the surface radiates as a black-body and the atmosphere is transparent. The latter is reasonably valid for the 8–13- μ terrestrial window used for the observations, but the first has been questioned by Öpik, who believes the emissivity to be closer to 0.75 than to 1, "by analogy with terrestrial substances". The net effect is to raise the Martian temperatures by about 5 per cent, that is, about 13° C, making the environment more hospitable to life. Actually there are few data in the literature on the emissivity of terrestrial surfaces; but at least one report⁸ indicates that the emissivities are higher. Even accepting this low emissivity and possible systematic errors, it seems unlikely that the summer temperature of *Depressio Hellespontica* could be raised to 0° C. Accepting this, and knowing the uninviting composition of the atmosphere, it appears highly improbable that any life, based on water as solvent, can exist in this region with the activity necessary to explain the darkening variations. Schemes can no doubt be envisaged to circumvent these objections, but they must surely be very special. If a non-life mechanism must be invoked to explain the seasonal change of the albedo for this one dark area, it is reasonable to assume it is applicable to the other dark regions and that this property cannot be used as an indication of

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life, even at the equator where the temperatures are more equable.

Together with the seasonal change in the albedo a concurrent variation in the visual polarization has been observed by Dollfus⁹⁻¹¹. For the autumn and winter seasons in a particular hemisphere the polarization of the corresponding dark areas has a negative minimum of about -0.012 at a phase angle of 11° , and then increases with a value of 0.0 occurring at 25° . In the spring and summer the dependence of the polarization on phase angle changes so that for the maximum difference, in late spring, the minimum polarization is -0.015 at a phase angle of 13° , and the zero point occurs at a phase angle of 30° . The shift in the polarization curve cannot be due to atmospheric effects but must arise from changes in the surface. Dollfus says this must be a change in the surface texture which in turn is most likely due to the proliferation of highly coloured micro-organisms when the water vapour from the subliming polar cap reaches a particular area. Attempts to duplicate the Martian behaviour using terrestrial biological samples on inorganic substrata were unsuccessful, but this is not a strong counter argument since life-forms are highly adaptable and would presumably differ on Mars from terrestrial ones.

However, there does not seem to be justification for relying so heavily on a life interpretation. If the argument on the seasonal albedo variation is accepted then presumably an inorganic interpretation must also be found for the polarization variation. Two possibilities based on the very extensive laboratory work of Dollfus¹² can be suggested. First, it is not necessary to invoke a change of texture to explain the change in the polarization curve. If the surface material becomes more absorbing in the spring then both the albedo and polarization will change in the manner observed. Although no suitable mechanisms have been proposed to produce this darkening, the possibility should not be overlooked. Secondly, a change in surface texture in which the surface becomes rougher will also explain the data. Dollfus has demonstrated such a difference between samples consisting of the same small particles but where one has a smoothed surface and the other a surface roughened by stirring. He concludes that the agglomeration of particles into larger entities increases the multiple reflexion of light in the surface and shifts the polarization curve. In the case of Mars, the surface could be roughened by the removal of small loose particles by appropriate winds. The material remaining would then be small particles partially cemented together into larger particles, perhaps similar to the "fairy castles" of Hapke and van Horn¹³.

The rejuvenation property of the dark areas is one aspect which can be basically accepted as pertinent, although, as Salisbury has pointed out, a lichen cover

would not be expected to behave in this manner. Higher forms of plant life such as Salisbury favours would possess this property.

While certain observations seem to favour life, others are very difficult to explain by this hypothesis. The normally bright region Hellas was dark during the 1954 opposition but returned in 1956 to its position as the second brightest area on the planet, only the polar caps exceeding it in reflectivity^{14,15}. Any form of plant life which, under Martian conditions, can so rapidly expand over and then retreat from an area of 290,000 square miles must be truly unique. Other non-seasonal changes in the extent of the dark and bright areas are equally difficult to explain by a life hypothesis.

As an alternative to the interpretation of life on Mars, I prefer an inorganic explanation based on ideas of McLaughlin¹⁵ and Kuiper¹⁶. Assuming volcanoes, both active and dead, and suitable winds, the phenomena can be interpreted in a reasonably consistent manner. Thus the temporary darkening of Hellas would be ascribed to a film of volcanic ash produced by an active volcano just prior to the 1954 observations. This volcano then became passive and the winds proceeded to scour the area (McLaughlin considers it to be a high plateau since "it is often snow-covered, and in winter forms a vast extension of the polar cap down to latitude 30°"), restoring it to its previous brightness. Other non-periodic changes would be explained in like manner, involving appropriate combinations of volcanic ash, lava and winds.

The regenerative feature according to Kuiper is then achieved by atmospheric circulation. Presumably this involves dust being blown on to the dark areas (postulated by Kuiper to be lava and not ash) during the late summer, autumn and winter, and then removed during the spring. Öpik objects to such an interpretation, his principal argument being that radiometric and polarimetric measurements indicate that "the soil of the dark areas seems to be of the same grainy nature as that of the bright areas". This is not convincing, since volcanic lava can have optical and thermal properties which are not dissimilar to those of the dark areas—similarity of certain optical and thermal properties for two materials does not guarantee that they are of the same nature. Öpik also states that the presence of life is indicated by the permanence of the dark markings in spite of the numerous extensive dust storms. Without a regenerative property "during millions of centuries the dust storms would have covered the entire planet with a deep layer of dust. . . ." The significance of this statement is decreased by his acceptance of a surface which has a non-uniform elevation (also see Dollfus¹⁴). This is intended not as a complete treatment of the volcanic-wind model but as an indication

of its real possibilities. I am inclined to favour it, although not rejecting the interpretation of life on Mars.

The question of life on Mars has intrigued scientists for decades. Owing to the possibility of being able to verify directly the life hypothesis in the very near future it is becoming a subject of widespread study. One approach is to determine if certain terrestrial organisms can exist, perhaps in a modified form, in the Martian environment. Workers in this field have been encouraged by the recent positive identification of water vapour in the Martian atmosphere^{17,18}. The second approach is to investigate whether the various observed Martian phenomena suggest that life exists there. It is to this area that the present article is addressed. On the basis of this brief discussion it is suggested that the life interpretation is very tenuous and that inorganic interpretations be given greater credence.

This work was supported by National Aeronautics and Space Association grant *NsG* 101-61.

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