

CONFIRMATION OF ANOMALOUS AREAS ("OASES") ON MARS FROM EARTH-BASED RADAR DATA. Zisk, S.H., Haystack Observatory, Westford, MA 01886 and Mouginis-Mark, P.J., Dept. of Geological Sciences, Brown Univ., Providence, RI 02912.

Introduction: Huguenin *et al.*^{1,2} have cited a variety of remote sensing data that they interpret to be consistent with anomalous near-equatorial regions of H₂O outgassing ("oases"). Although not providing a unique characterization of surface chemistry, Earth-based radar measurements of the martian surface would be expected to show some anomaly for any region containing liquid water. This radar anomaly would be the result of the very large value of radar reflectivity at the atmosphere/water interface, and also the high radar absorbtivity of damp or even hydrated soils. Radar therefore provides an additional test for resolving the possible existence of martian oases.

Earth-based radar measurements of the martian surface were carried out at the Jet Propulsion Laboratory's Goldstone Facility by Downs and others in 1971-1973,³ and the resultant data kindly made available to us by Dr. Downs. In addition to providing topography and local slope estimates,^{3,4} the Goldstone data provides the mean dielectric constant and smoothness of the surface over the radar resolution cell.² Coverage between 1971-1973 was obtained for martian latitudes 14°S to 22°S for almost the entire circumference of the planet.

Data: The entire Goldstone radar data set (~32,600 data points) was searched by us to locate areas that possess both anomalously high reflectivity and smoothness ("c-factor," ref. 5) values. A pairing of reflectivities >9% and c-factors >3200 (rms slope <1.0) were employed in this search mode. Fig. 1 illustrates the aerocentric positions and number density of these high-reflectivity, high-smoothness measurements. Only two regions on the planet are identified by this technique. Very prominent is a region centered at 17°S, 85°W, in addition to two smaller areas to the northwest of Hellas: remarkably close to the Solus Lacus and Noachis-Hellespontus Oases proposed by Huguenin *et al.*^{1,2}

There is little doubt of the reality of these anomalous areas. The measurements presented in Fig. 1 include data from both the 1971 and 1973 conjunctions. Almost no randomly-located point measurements appear over the rest of the planet, despite the near global coverage of the data set between 14°S-22°S. Nor have we found that a change in contour levels, from 9% to 11% reflectivity or 3200 to 2400 c-factor, causes any significant change in the shape or number of areas identified.

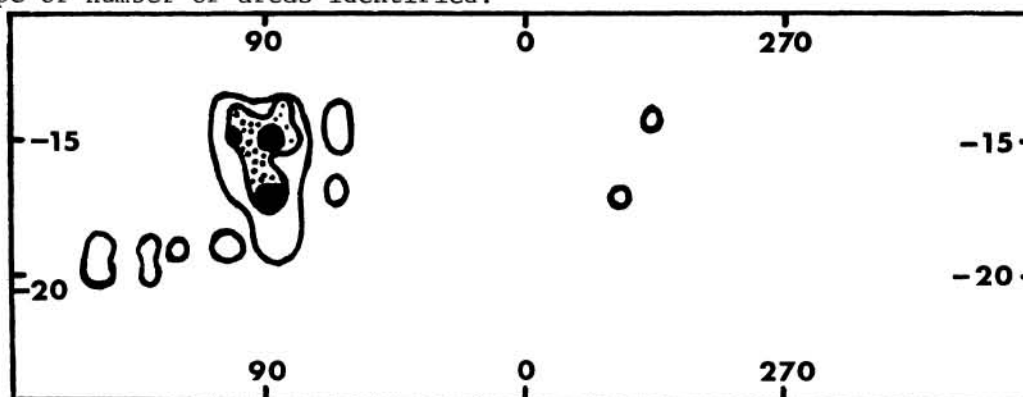


Fig. 1: Distribution of point measurements with both reflectivity greater than 9% and c-factor greater than 3200. Data, located between 14-22°S for entire circumference of planet, contains approximately 32,600 point measurements. Shown here is the number of 1° lat. x 5° long. ample bins with any (open), more than 10 (stippled) and more than 36 (black) point occurrences of these radar returns.

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Use of the acquisition dates for the Goldstone data permit the Solus Lacus measurements to be subdivided on the basis of martian season. The 1971 and 1973 data were taken during local spring (L_S 216-256) and local summer (L_S 249-288) respectively. These measurements are the only ones which appear as anomalies in Fig. 1. Additional data were also collected during the 1972 martian conjunction, which corresponds* to local winter in the southern hemisphere (L_S 112).

Fig. 2A presents the mean reflectivity values for each opposition as a function of aerocentric longitude. Additional confirmation of the anomalous nature of the Solus Lacus region can be derived by noting that east of $83^\circ W$, the reflectivity values are consistently lower than 8%--a value comparable to other surface materials on Mars.^{6,7} Adequate calibration of the data for all three oppositions is also illustrated by the region $80-83^\circ W$, because for each year virtually the same reflectivity values were obtained.

Between $83-93^\circ W$, clear seasonal variations in the reflectivity values are observed.* For the summer measurements, mean reflectivities may be as high as 12.8%, while the maximum spring value is 10.2%. Maximum spring and winter values are similar, but frequently winter minima fall to 7%, while spring remains at $\sim 9\%$. A systematic seasonal relationship, involving high-summer, intermediate-spring and low-winter reflectivities for the same latitudes and longitudes, is revealed in Fig. 2B,* which normalizes spring and summer values to those obtained at that longitude during winter.

Discussion: Measurements showing a high radar reflectivity (high dielectric constant) would be expected not only for water surfaces, but also for large areas of smooth rock at or near (~ 1 meter depth) the surface. Anorthositic rock, with a dielectric constant of about 5, would have a reflectivity of about 15% if the entire surface area covered by the radar cell ($\sim 12.5 \text{ km}^2$) were within this material. Because photogeological analysis of Solus Lacus⁷ reveals many large craters and a pitted surface at an image resolution of about 10 meters, explaining the observed high reflectivity by invoking a regionally smooth surface is untenable. The seasonal variability* of the reflectivity values obtained is also very difficult to explain by hypothesizing an annually variable, very smooth, solid rock surface. Conversely, the transition from water ice to liquid water produces exactly the observed radar response, due to striking changes in the dielectric properties of the water as the ice melts.

We therefore have to conclude that only surface materials containing liquid water are consistent with: 1) the high summer reflectivity; 2) the observed surface morphology; and 3) the increase in reflectivity values as Solus Lacus experiences a seasonal change* from winter to summer. Some inferences can also be made about the regional extent of the liquid water at Solus Lacus. An extensive liquid water surface (e.g., a lake) would have a much higher reflectivity than the observed maximum value of about 16%. More likely is a transitional zone of damp soil, which produces a more gradual change in complex dielectric constant (i.e., including dielectric loss-tangent), and hence a smaller observed reflectivity, than an abrupt interface. Alternatively, the liquid water may only sporadically be within one meter of the surface, so that the observed reflection values are a mixture of high water returns diluted with returns from the interspersed dry soil or rock surfaces. If this second situation is applicable, the c-factor measurements would depend on the highly reflecting regions (i.e., the "oases") rather than the dry intervening areas.

*There remains a question about the detailed seasonal variations reported here, specifically, values for L_S we have used. This question is being resolved.

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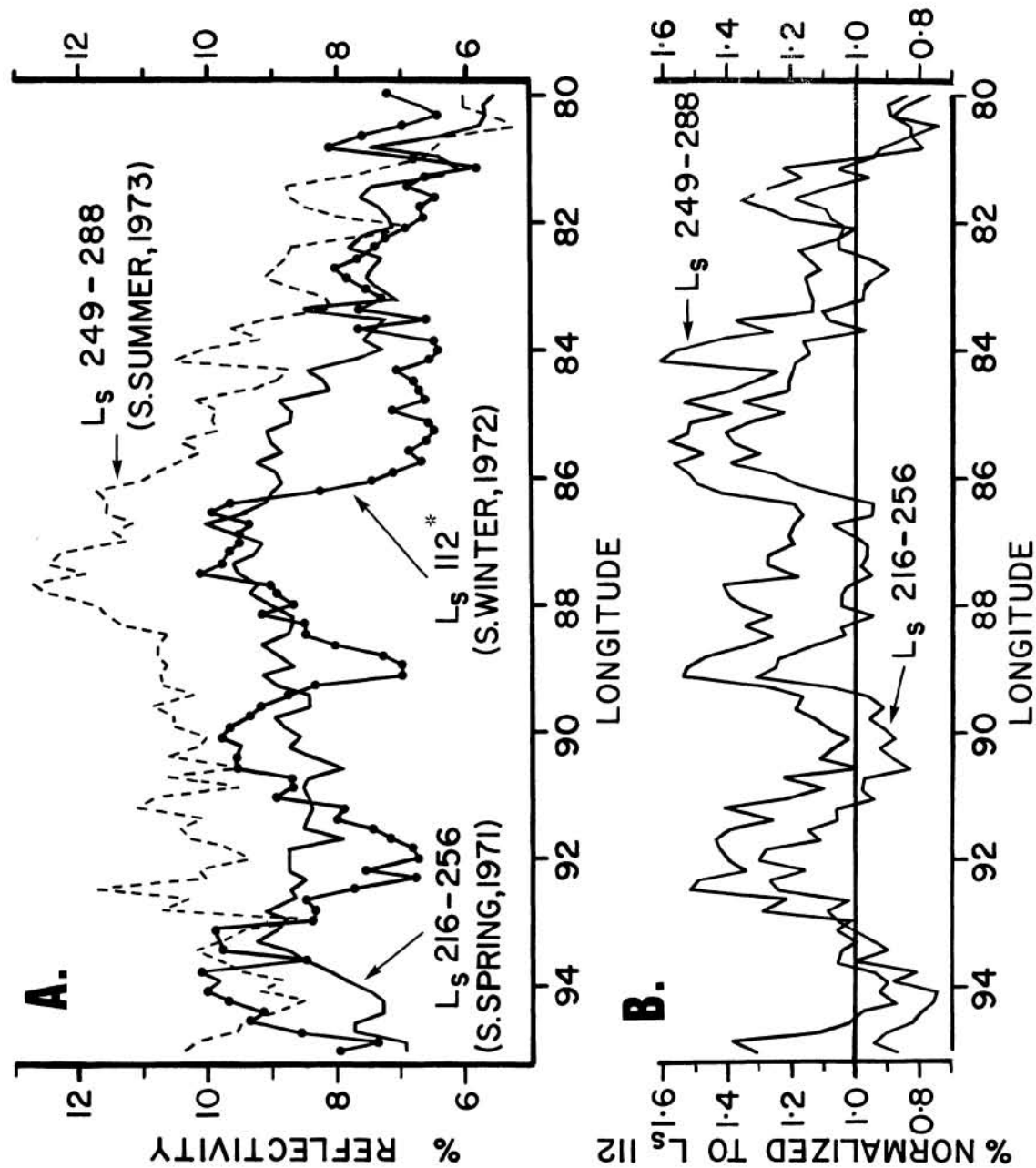
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Fig. 2: A) Mean reflectivity values for local spring, summer and winter. Data includes 1316 point measurements, derived from 14 radar swaths.² Summer and spring measurements are mean values of six radar swaths each, winter is for two radar swaths. Sample bin size is 0.16° longitude. B) The seasonal character of reflectivity returns is shown here by dividing the summer and spring values at each longitude by the respective winter value. Data base same as Fig. 2A.

References: ¹Huguenin *et al.* (1979) NASA-TM 80339, 208. ²Huguenin and Clifford (1979) *Bull. Am. Astro. Soc.* 11., 580. ³Downs *et al.* (1975) *Icarus* 26, 273. ⁴Roth *et al.* (1980) Submitted to *Icarus*. ⁵Hagfors (1964) *J. Geophys. Res.* 69, 3779. ⁶Mouginis-Mark and Zisk (1980) this vol. ⁷Mouginis-Mark *et al.* (1980) this vol.