GUSEV AND MERIDIANI WILL LOOK DIFFERENT: RADAR SCATTERING PROPERTIES OF THE MARS EXPLORATION ROVER LANDING SITES.

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Introduction: Analysis of all existing radar data for the two Mars Exploration Rover (MER) landing sites at Meridiani Planum and Gusev Crater suggest that their meter-scale morphological appearance will be noticeably different than previous Mars landing sites; their "human-scale", decimeter- to meter-scale roughness is not the same as for previous Mars landing sites. We make this prediction based on a comparison of the MER landing sites.

Radar Data: Earth-based radar observations of Mars have been ongoing since the 1960's, with some quantitative data even surviving from the earlier observations. The observations have been carried out at both 12.6 cm (S-band) and 3.5 cm (X-band) wavelengths using circularly polarized transmitted signals. The echoes can then be received in both the same sense of circular polarization (SC) and opposite sense of circular polarization (OC).

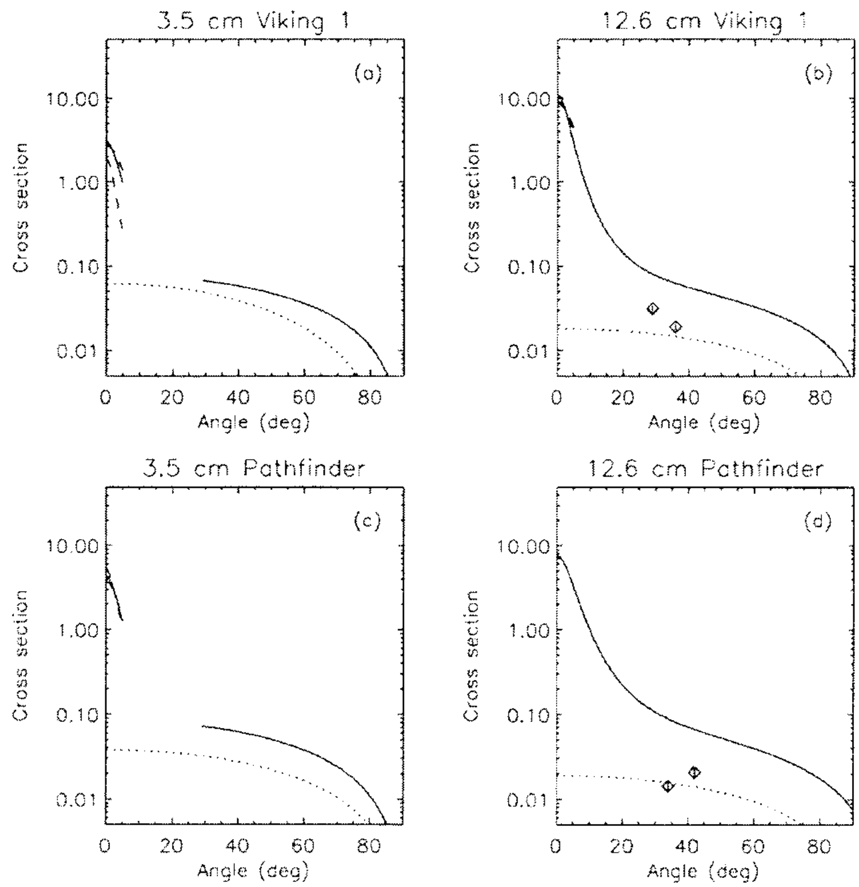

Figure 1. Radar scattering properties of the Viking 1, panels (a) and (b), and Mars Pathfinder landing sites, panels (c) and (d). Solid lines are OC polarization and dotted lines are SC polarization. The left-hand panels are for X-band and show GSSR quasi-specular delay-Doppler Hagfors model fits and G-VLA diffuse scattering cosine model fits. The dashed lines show the range of values from the GSSR fits. The right-hand panels are for S-band and show the *Moore and Thompson* [1] OC and SC scattering models for the units in which the MER landing ellipses are located. The points at $\theta \sim 30°$ are SC cross section determinations by [2]. The Viking 1 dashed line data are (also) from [2].

Quasi-specular scattering data. Mirror-like reflections of circularly polarized radar energy dominates the OC echoes at small incidence angles, θ, less than about 20°, because these quasi-specular reflections cause a polarization flip. The behavior of the radar cross section as a function of θ is well-modeled for Mars by the Hagfors model [3]. The mirror-like reflections are understood to be controlled by radar-facing facets with characteristic length-scales from 10x to 100x the incident wavelength.

Quasi-specular scattering model parameters are obtained from delay-Doppler radar experiments, which have been performed by the Goldstone Solar System Radar (GSSR) at S- and X-bands, and the Arecibo Observatory radar at S-band.

Diffuse scattering data. At all incidence angles radar energy is diffusely scattered and multiply scattered by interaction with surface roughness elements at the scale of the incident wavelength, and produce echoes in both OC and SC polarizations. This scattering mechanism dominates the radar cross section for θ greater than about 30°. Diffuse backscatter incidence angle dependence is described with a cosine model. Here we use the amplitude of the diffuse backscatter component is a comparative measure of the wavelength-scale roughness of the target surface.

Diffuse scattering model parameters have been obtained from monostatic continuous wave (CW) radar observations of Mars by both GSSR and Arecibo, as well as by interferometric imaging with the Very Large Array (VLA) of GSSR CW illumination of Mars. Long-code method delay-Doppler imaging by the Arecibo Observatory also produces radar cross sections at large incidence angles.

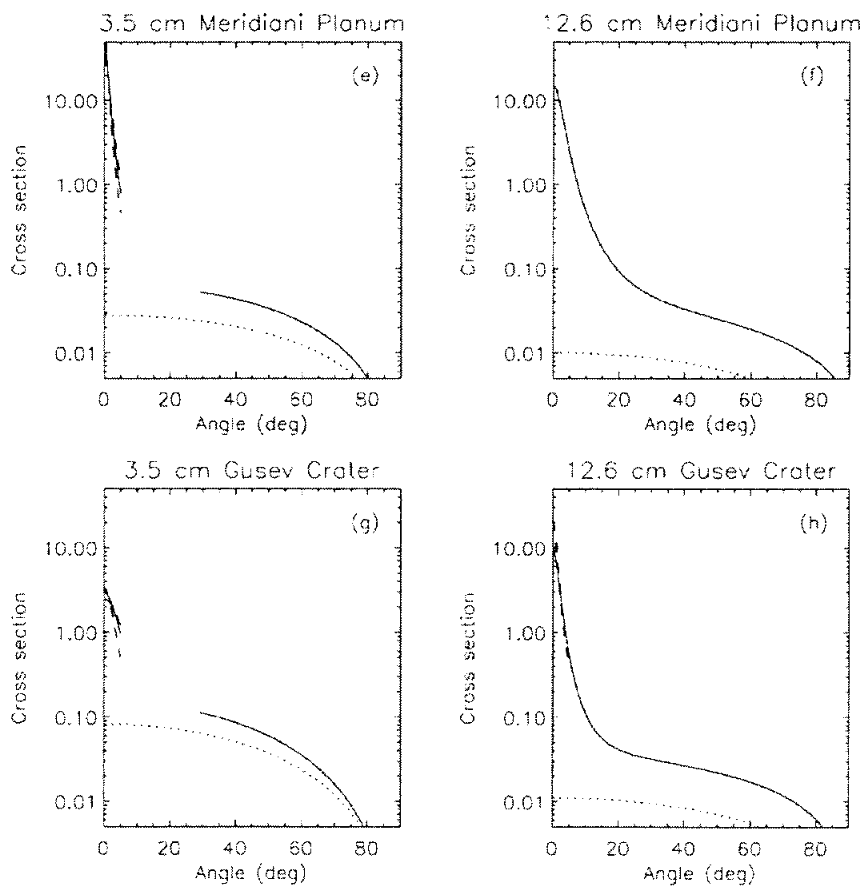

Figure 1. con't. Radar scattering properties of the Meridiani Planum, panels (e) and (f), and Gusev Crater, panels (g) and (h), MER landing sites. Solid lines are OC polarization and dotted lines are SC polarization. The left-hand panels are for X-band and show GSSR quasi-specular delay-Doppler Hagfors model fits and G-VLA diffuse scattering cosine model fits. The dashed lines show the range of values from the GSSR fits. The X-band GSSR data at Gusev crater are for the same geologic unit as the crater, but are not inside the crater. The right-hand panels are for

S-band and show the *Moore and Thompson* [1] OC and SC scattering models for the units in which the MER landing ellipses are located. The dashed line quasi-specular data for Gusev crater is from GSSR [4].

Landing Sites: Radar data have been used to characterize past Mars landing sites [e.g. 5, 6], and the MER landing sites are no exception, since the MER landing system needs both radar reflectivity and appropriate levels of surface roughness.

In Figure 1 we plot the incidence angle behavior of radar cross-section for OC and SC polarizations at both X- and S-bands using data from various sources. We qualitatively analyze the data here, by comparing the radar backscatter behavior of the MER sites to the Viking Lander 1 (VL1) site and the Mars Pathfinder site (the Viking Lander 2 site is not considered because it is too far north to obtain direct quasi-specular information). More quantitative analyses will be presented at the meeting.

Meridiani Planum. The quasi-specular component at both X- and S-bands in the OC channel is significantly enhanced with respect to VL1 and MPF site. This indicates that 35 cm to 12 m length-scale roughness will be much less than the previous sites. The diffuse backscatter components are lower than the older sites too, thus the decimeter roughness will also be less than previously seen at the surface of Mars.

Gusev Crater. The X-band quasi-specular GSSR data for the geologic unit mapped inside Gusev are actually from the same unit at another location. Nevertheless, the lower level of the quasi-specular cross-section could suggest either that the 35 cm to 3.5 m roughness is somewhat greater than at VL1 or MPF, or that the surface is less radar reflective. Gusev thermal inertia measurements would suggest that either the former or a combination of the two interpretations is correct. The enhanced X-band diffuse cross-sections along with the reduced S-band diffuse cross-sections suggest that roughness at the suface is more important at 3.5 cm than at 12 cm. At the quasi-specular length-scale of interest for the S-band data from GSSR in 1973 (dashed) suggest that the Gusev ellipse exhibits greater roughness at 35 cm to 3.5 m than at 1.2 m to 12 m. This distinct scale-dependence of roughness in the meter-range is not observed at VL1 or MPF.

Conclusion: The radar backscatter properties of the selected MER landing sites are distinct from the Viking 1 and Mars Pathfinder sites. The images taken by the MER cameras on the surface will show a terrain that is morphologically different at "human scales" from those previous Mars landing sites.

References: [1] Moore H. J., and Thompson T. W. (1991) *LPS XXI*, 457-472. [2] Harmon J. K. (1997) *JGR*, *102*, 4081-4095. [3] Hagfors T. (1964) *JGR*, *69*, 3779-3784. [4] Downs G. S., Reichley P. E., and Green R. R. (1975) *Icarus*, 273-312. [5] Masursky H., and Crabill N. L. (1976) *Science*, 809-812. [6] Haldemann A. F. C. et al. (1997) *JGR*, *102*, 4097-4106.

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