

THE BASAL DETECTABILITY OF AN ICE-COVERED MARS BY MARSIS. C. Grima¹, J. Mouginot², W. Kofman^{3,4}, A. Hérique³ and P. Beck³. ¹Institute for Geophysics, University of Texas at Austin, TX, USA, (cyril.grima@utexas.edu), ²Univ. Grenoble Alpes, CNRS, IGE, 38000 Grenoble, France, ³Univ. Grenoble Alpes, CNRS, CNES, IPAG, 38000 Grenoble, France, ⁴Centrum Badan Kosmicznych Polskiej Akademii Nauk (CBK PAN), PL-00-716 Warsaw, Bartycka 18A, Poland.

Introduction. The detection of anomalously strong relative basal reflectivity beneath the Martian South Polar Layered Deposits (SPLD) from the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) has led to hypotheses suggesting the presence of basal materials such as liquid water [1, 2]. The main metric that has been used to assess the reflective strength of the SPLD/bedrock interface is the relative basal reflectivity defined as the power ratio of the subsurface echo against the surface echo P_{ss}/P_s [3]. At the location where the bright radar return is, P_{ss}/P_s at 4 MHz is consistently measured higher than 0 dB with a median at about 2.5 dB. It exhibits excursions above 5 dB, but rarely exceeds 10 dB [1, 2, 4].

Here, we propose a forward approach to assess whether such a high signal could be produced by a Martian terrain currently exposed at the surface without liquid water. We convert existing MARSIS surface reflectivity measurements into a basal reflectivity in order to calculate a P_{ss}/P_s as if the Martian current surface were overlaid by an SPLD-like ice deposit with thickness and properties similar to what is assumed by Orosei et al. [1].

Method Usually, analytical methods, numerical models, or laboratory/field analogs are used to search for materials that could produce such strong basal reflections [5, 6, 2]. However, MARSIS also provides planet-wide surface reflectivity measurements that consequently span the most exhaustive range of terrains that could be geologically produced on the planet, with the acknowledged caveat that their composition is not as well known as laboratory-investigated materials [7]. Mouginot et al. [7] provide processed surface reflectivity for the 3, 4 and 5 MHz bands. Here we use exclusively the 4-MHz band for it has the largest spatial coverage. It is also the main frequency used by Orosei et al. [1] and Lauro et al. [2] to illustrate and quantify the bright basal reflector at the SPLD. Data are binned into a spatial grid made of $0.5^\circ \times 0.5^\circ$ cells. The median of the linear surface reflectivity power is considered for each cell. P_{ss}/P_s for the whole Martian surface is essentially calculated from the following equation:

$$\frac{P_{ss}}{P_s} = \frac{R_{23}}{R_{12}} T_{12}^2 A_2 \quad (1)$$

where R_{ij} (resp. T_{ij}) is the reflection (resp. transmission) coefficient between medium i and j . and A_2 is

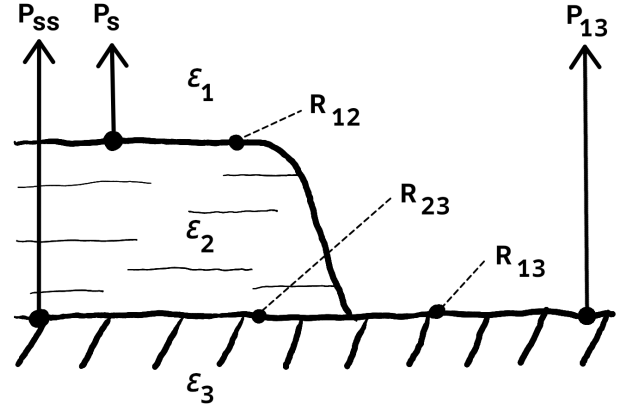


Figure 1: Considered geophysical setting. Subscripts 1, 2 and 3 refer to the atmosphere, the ice and other terrains, respectively

the expected attenuation within the ice. The considered geophysical settings is depicted on Fig. 1. The fictive basal reflectivity R_{23} for the entire planet is derived from the surface reflectivity R_{13} measured by MARSIS. R_{12} is the measured reflectivity of the surface of the SPLD above the location of the bright detection. All the other terms in eq. are determined from assumptions on the ice properties

Results We use assumptions for the ice properties that are similar to those made by Orosei et al. [1]: a volumetric impurity rate of about 10 % [8, 9]. This translates to a relative permittivity of $\epsilon_2 = 3.4$, a loss tangent of $\tan \delta_2 = 0.001$ and an ice thickness of 1400 m [1, 2]. Under these conditions, about 2% (resp. 0.3%) of the surface would produce a positive (resp. > 5 dB) relative basal return P_{ss}/P_s , equivalent to the radiometric signature observed for the bright basal reflectors at the SPLD. Fig. 2 provide location where bright basal echoes would occur if they were covered by an SPLD-like ice sheet.

Discussion Most of the detected bright regions are related to terrains of igneous origin, but all volcanic terrains do not exhibit such a strong signal. Of note, these regions do not share a common geological epoch but are spread over a large timescale from late Noachian to late Amazonian.

Orosei et al. [1] determined permittivity > 15 for the bright basal SPLD reflectors with the assumption of neg-

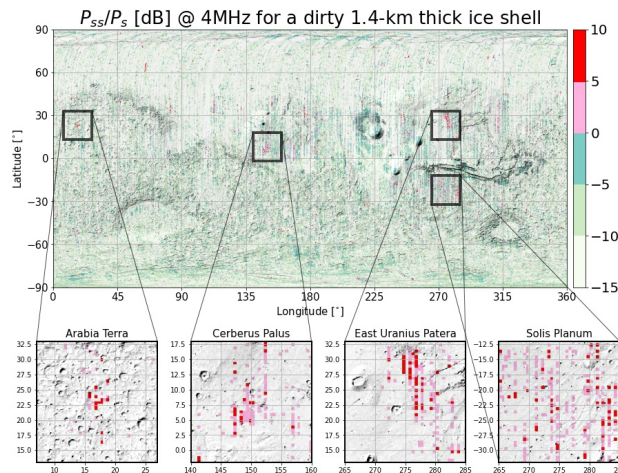


Figure 2: Relative basal echo strength of Mars if the surface was entirely covered by an 1.4-km dirty ice sheet (10% volume impurity rate). Bottom inserts display only positive values for better identifications relative to the regional landforms. The maps are shaded with the Mars Orbiter Laser Altimetry (MOLA) data.

ligible conductivity. Because we use similar assumptions for the ice dielectric properties, one can expect the bright volcanic regions detected in this study to exhibit a similar range of permittivity. The possibility for igneous material to be that bright is sparsely documented but the literature suggests that it could be achieved from the combination of both a dense and Ilmenite-rich material (an Iron-Titanium oxide mineral, $FeTiO_3$) [10, 11, 12, 13].

It draws attention that the brightest terrains across the planet would produce basal echoes with a radiometric character in the range of the brightest ones observed at the SPLD by Orosei et al. [1] and under similar assumptions for the composition of the overlying ice. This radiometric similarity (or continuity) is indicative of the likelihood for a non-wet generic material currently available at Mars to be responsible for the bright basal SPLD reflection.

A complete version of this work is available in [14]

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