**THE GEOELECTRICAL PROPERTIES OF ATHABASCA BROKEN-RAFTED PLATE TERRAIN AS DERIVED FROM THE MARSIS RADAR SOUNDING DATA.**
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**Introduction:** To assess the potential distribution and state of the martian subsurface water (both ice and liquide form) [1], two low-frequency radar sounders, MARSIS (Mars Advanced Radar for Subsurface and Ionosphere Sounding on board the Mars Express spacecraft) [2] and SHARAD (the Shallow Radar instrument on board the Mars Reconnaissance Orbiter) are currently probing the electromagnetic properties of the upper crust.

In this effort, we investigate the geoelectrical properties of the Athabasca subsurface (5°N, 150°E, Fig. 1) derived from MARSIS radar data in order to test the formation hypotheses of the rafted-plate morphology observed in this Martian area [3]. To achieve this goal, we compare the MARSIS backscattered traces with those generated by finite-difference time-domain (FDTD) radar simulations based on volcanic [4, 5] and fluvial [3] subsurface geoelectrical models whose dielectric properties have been assigned based on laboratory measurements of analog materials [6,7].

**Site of interest:** High Resolution Stereo Camera (HRSC) images of the vicinity of Athabasca Valles area reveal a surface with a broken, rafted-plate morphology. Two formation hypotheses have been proposed to explain this appearance. The first hypothesis is a fluvial one which attributes the local morphology to the discharge and freezing of a large volume of groundwater [3]. The second hypothesis involves the crystallization of a low-viscosity lava flow [5].

**Geoelectrical models:** Based on the latest geological and geophysical observations over this area, we constructed two geoelectrical models of the shallow subsurface which were used as the basis of our FDTD radar backscatter simulations (Fig. 1, right bottom). Both geoelectrical models include a 10-m-thick top layer of basaltic ash. But, the composition of the 45-m-thick second layer differentiates the two models. In our “fluvial” model (Model 1, Fig. 1), this second layer is composed of 80% ice and 20% basaltic ash while our “volcanic” model (Model 2, Fig. 1) has a 20%-ice, 80%-basalt composition. The third and final layer in both models is a basement of andesitic basalt [8].

**Methodology:** To investigate the geoelectrical properties of Athabasca subsurface, we use the MARSIS 5-MHz-band radar data obtained from Mars Express orbit 4092, acquired during night-time and corrected from ionospheric distortion. The profile were acquired along a track that extends from 0° to 10° N latitude and is centred on 149.17° E longitude (Fig. 1). To reduce the effects of surface clutter on the MARSIS data, we focused our study between 4.5°N and 9°N where the surface roughness as determined from the MOLA topography is very low. We then calculated the averaged backscattered echo strength (in dB) over this same ground-track interval (Fig. 2, black thick line). The loss rate generated by the subsurface is equal to the line slope.

To study the MARSIS radar-wave propagation in the Athabasca subsurface, we used the FDTD technique that solve Maxwell's equations in discrete steps of time and space [9]. The depth of the simulation space is 500 m and its width is 3 km $\times$ 3 km The emitted signal is then modelled as a modulated Gaussian plane wave with a central frequency of 5 MHz. We used this approach to simulate radar-wave propagation through both geoelectrical models. We then obtained the magnitude of the backscattered electric field as a function of propagation time. To maintain consistency with the MARSIS data processing, we calculated the signal losses in dB as a function of propagation time and depth (Fig. 3).

**Results:** Calculating the loss rates of the mean backscattered radar echo between 4.5° and 9°N (Figure 2) yields an average value of 0.09 dB/m for the first 160 m of the subsurface. This result indicates that the near-surface of Athabasca is composed of a relatively conductive material.

A comparison of the simulated backscattered radar echoes from the two models allows us to investigate the influence of subsurface ice content on the propagation of the MARSIS radar signal at 5 MHz. The average loss rate for the ice-rich model (Model 1) is 0.048 dB/m (Fig.3, A). In contrast, the mean loss rate associated with the ice-poor basaltic model is 0.10 dB/m (Fig. 3, B). The different loss rate between the two geoelectrical models demonstrates how a higher ice-to-basalt ratio can considerably reduce signal losses.

**Discussion:** The observed loss rate of the MARSIS signal over this region averaged ~2 times greater than that produced by the ice-rich subsurface model in our simulations – but very similar to the losses associated with our ice-poor basaltic model. This agreement is most consistent with a volcanic origin of the broken, rafted-plate terrain in the vicinity of Athabasca.

This study is part of our effort to understand the geoelectrical properties of the martian subsurface and its implication in the investigation of the potential occurrence and distribution of ground ice and groundwater in the Martian equatorial subsurface.

**References:** [1] Clifford S.M. and Parker T.J. (2001) *Icarus*, 154(1), 40-79. [2] Picardi G. et al. (2004) *Planet. Space Sci.,52*, 149–156. [3] Murray J.B. et al. (2005) *Nature*, 434, 352-355. [4] Plescia J.B. (2003) *Icarus*, 164, 79-95. [5] Jaeger W.L. et al. (2007) *Science*, 317, 1709–1711. [6] Heggy E. et al. (2006) *JGR*, 111, 1-16. [7] Farr T. et al. (2001), *National Research Council Planetary Decadal Study, Terrestrial Analogs to Mars*. [8] Christensen P.R. et al. (2001) *JGR*, 106, 23,823-23,871. [9] Heggy E. et al. (2003) *JGR*, 108, E4, 11,1-11,10.

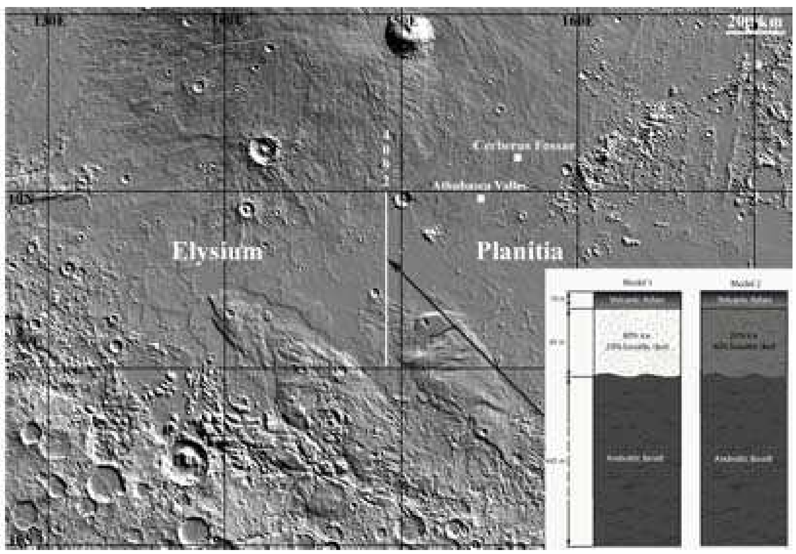


Fig. 1. Context map of the Athabasca study area within Elysium Planitia. The ground track of the MARSIS data acquired on orbit 4092 is indicated by the white line - Right-bottom : Schematic cross-sections of the “fluvial” (Model 1) and “volcanic” (Model 2) Athabasca geoelectrical models.

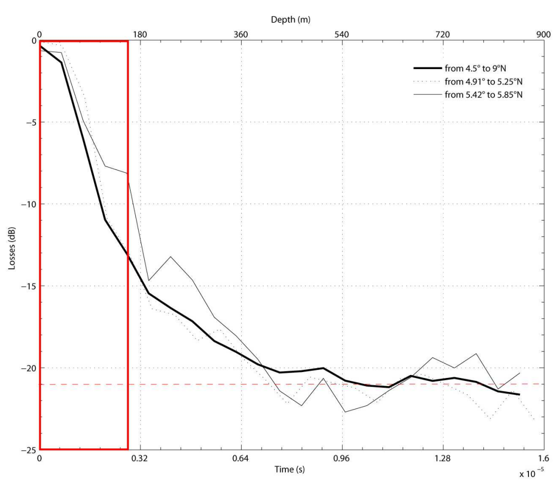


Fig. 2. The radar-echo losses (dB) for different frames between 4.5 and 9°N versus range delay time (s) and depth (m), assuming a mean dielectric constant of 7.6. The dashed red line represents the noise level. The red box corresponds to the first 160 m where we calculated the loss rate.

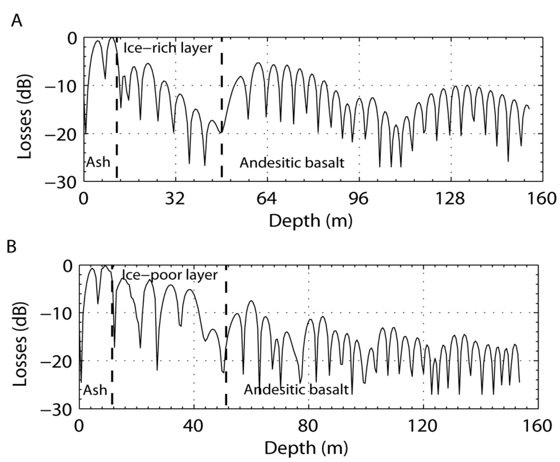


Fig. 3. FDTD simulated radar-echoes losses for A: Model 1 (80% ice in Layer 2) and B: Model 2 (20% ice in Layer 2). Black dashed lines represent the interfaces between the different geoelectrical materials.