POSSIBLE GEOLOGICAL SCENARIOS FOR THE MARSIS EXPERIMENT. S. Di Lorenzo, A.P. Rossi, *Int'l Research School of Planetary Science, Universita' G. D'Annunzio, viale Pindaro 42, 65124, Pescara, Italy, (dilo@irsps.unich.it).*

Introduction

Two radar instruments with different penetration capabilities, MARSIS and SHARAD, will fly to Mars in the next years. The MARSIS radar experiment, which will be on board the Mars Express mission, will be the first to analyze the characteristics of the subsurface of Mars. In this work we suggest models for a few areas of Mars with different geological settings. This stratigraphical analysis will help us to understand how MARSIS detects geological features in the upper crust of Mars.

The surface of Mars is characterized by a variety of geological processes and provinces which are likely to be related to different subsurface structures, however very little is known of the subsurface of Mars. The aim of this work is to simulate the MARSIS response on plausible geological scenarios and help in interpreting future data acquired by the instrument.

MARSIS is a low-frequency nadir-looking pulse limited radar sounder and altimeter with ground penetration capabilities. It can transmit signal with 1.8, 3, 4, 5 MHz and 1MHz bandwidth with the lowest frequencies used nighttime to probe the subsurface. Echo profiles will be collected at two different frequencies in order to separate the subsurface reflection and a monopole antenna will collect echoes to reduce the clutter effect from the surface. The nominal vertical resolution in the crust of the processed signal is 50-100 m depending on the wave propagation speed. The size of the footprints at the surface will be of about 5 by 10 km. MARSIS will obtain up to 4 echo profiles at intervals of about 1 second resulting in a spatial sampling rate of 5 km along-track [1]. The goal of MARSIS is to map the distribution of water in the uppermost portion of the Martian crust looking for the interface between ice/liquid water and secondary objectives are subsurface geologic probing and a ionospheric sounding.

Geological Framework

In order to investigate the upper crustal structure of the planet with ground penetrating radar, forward modeling could be a key technique. A preliminary selection of targets for the radar response simulation includes large impact craters, sedimentary basins, volcanic edifices and tectonic structures. Thus, we have tried to focus our study on a few examples, hypothesizing geologic models and using them for simulating the radar response. We have chosen locations where morphologies from Viking and MOC images and MOLA topography could help us in describing the possible subsurface layers. MOC images have shown several outcrops of 2-4 km thickness with layered deposits. The different characteristics of each layer suggest that the Martian upper crust has been sculptured by a wide range of geological processes and the Martian subsurface is reasonably complex as well.

A portion of the Ganges chasma has been chosen as an example of the walls of the Valles Marineris where layers are visible even from Viking images and several layered deposits appear in the bottom of the valley on MOC images. Presence of water is suggested by surface morphologies and possible fluvial erosion and deposition [2]. We have chosen a location in the Utopia Planitia for which buried structures have been suggested [3] and Mars Odyssey neutron spectrometer maps indicate a permafrost layer extending up to the first meter [4]. Tharsis province will also be studied with a similar approach. The Holden Crater example is shown in this abstract [Fig. 1].

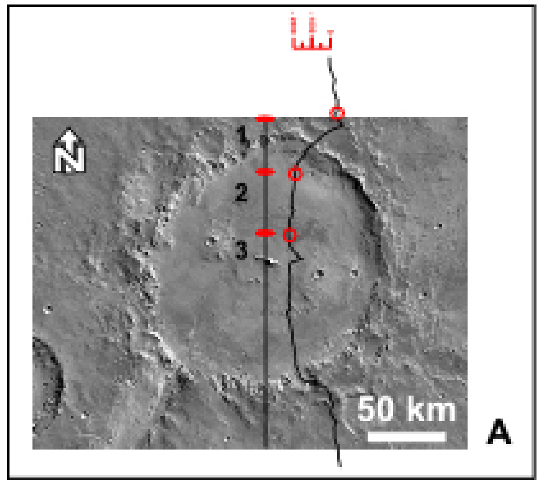

Figure 1: Viking mosaic of Holden Crater ($27.1^\circ S$,$34.7^\circ W$) with MOLA profile extracted from gridded data on it. It appears an old crater with complex shape and a central peak, it is about 140 km wide. Location of the stratigraphic sections 1,2 and 3 are shown on a longitudinal section of the crater

It represents a large crater structure with suggested fluvial and lacustrine deposits [5]. On Earth the sedimentary deposits associated with lacustrine or fluvial environments are characterized by well defined geometrical pattern, the boundaries of the bedding are formed by petrophysical discontinuities with different dielectric constant, so the penetrating radar should provide a reliable mapping of the internal geometries. These sediments are likely to have a high porosity, and the nature of the pore fill will affect the dielectric constant as well. Several deltas and terraces related to lacustrine/fluvial environments have been found on the Martian surface [6,7] with horizontal dimension going from a few hundreds of meter up to several kilometers [7,8], the spatial resolution of MARSIS would not probably allow the reconstruction of the internal sedimentary pattern for deltas, fro which we have to wait for SHARAD. Since there are evidences that several lacustrine basins have been active during the Amazonian [9,10] there is a possibility that they have a shallow groundwater reservoir which would give a strong radar response.

Model

Stratigraphic sections have been schematized with horizontal layers of different thickness and characterized by different dielectric properties and porosity. The real part of the dielectric constant and the tangent loss, have been estimated with a model used for the first part of the lunar crust that takes into account rocks density and iron oxides content [11], confronted with other values available from literature and found to be consistent in many cases.

Volume fraction of iron oxides has been derived from the APX spectrometer for the first dust layer and hypothesized for the deep layers.

The material considered filling the pores are ice, liquid water and air. We used the maps of the Odyssey neutron spectrometer to see if extend the permafrost layer in our simulation up to the first meter. We used the Clifford model [12] for the martian hydrosphere with a mean values of $220^\circ K$ for surface temperature, $2.0 W \cdot m^{-1} \cdot^\circ K^{-1}$ for the mean crustal thermal conductivity and $\Delta T = 0.015^\circ K \cdot m^{-1}$ for the geothermal gradient on actual Mars and we have set the ice/liquid (actually water brine) interface at 2.2 km of depth.

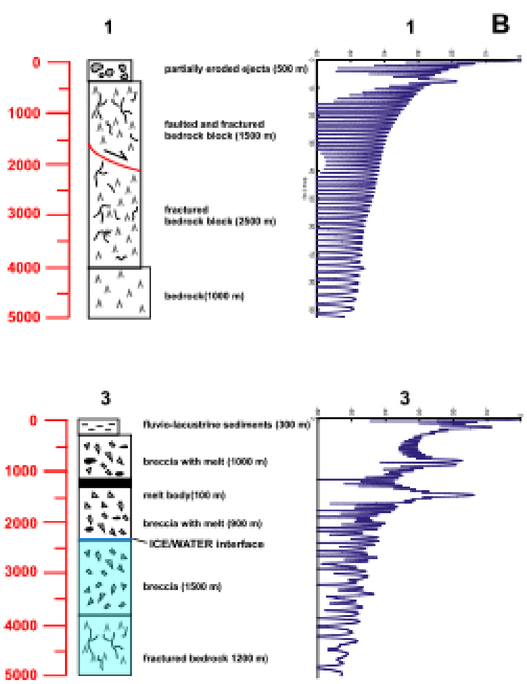

Figure 2: Example of possible MARSIS responses for selected sites in Holden Crater. Possible stratigraphic sections used in the simulations and MARSIS simulated radargrams of locations 1 and 3 at $1.8 MHz$ (the lowest frequency used only on night side). Horizontal scale are in dB and vertical scale is in μs.

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Example of the test performed on hypothesized stratigraphic columns across the Holden Crater are shown in Fig. 2-3.

Results

Preliminary results show that sequences of thick layers can be distinguished, even for high attenuations, up to depth of more than 3 kilometers for the lowest frequency. Large scale subsurface geometries can be recognized with a series of shots. The ice/liquid water interface detection results strongly dipendent to rocks porosity variations.

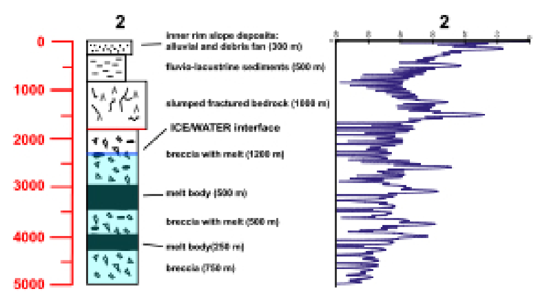

Figure 3: Possible stratigraphic sections used in the simulations and MARSIS simulated radargrams of the location 2 at $1.8 MHz$. Horizontal scale are in dB and vertical scale is in μs.

References

[1] G. G. Ori *et al.*, LPSC XXXIII (2002), abs.1503 [2] R. Kuzmin *et al.*, Second Mars Surveyor Landing Site Workshop, p. 61 [3] J.W. Head, LPSC XXXII (2001), abs. 1063 [4] W.C. Feldman *et al*, Science 297 (2002), 75-78 [5] K.P. Florenskii, Icarus 26 (1975), 219-229 [6] G.G. Ori *et al*, PSS 44 (1996), 1303-1315 [7] N.A. Cabrol *et al*, LPS XXXI (2000), abs. 1504 [8] N.A. Cabrol *et al*, Icarus 142 (1999), 160-172 [9] G.G. Ori *et al*, JGR 105 (2000), 17629-17642 [10] N.A. Cabrol *et al*, LPS XXXI (2000), abs. 1162 [11] G.R. Olhoeft *et al*, EPSL 24 (1975), 394-404 [12] S.M. Clifford, JGR 98 (1993), 10973-11016 [13] E. Heggy *et al*, Icarus 154 (2001), 244-257