Selection of Mars areas to be properly investigated using MARSIS radar data.

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Introduction

Mars Express is Europe's first spacecraft to the Red Planet. The spacecraft has been orbiting Mars since December 2003, carrying a suite of instruments that are investigating many scientific aspects of this planet in unprecedented detail. The observations are particularly focused on martian atmosphere, surface and subsurface.

The MARSIS Instrument

The most innovative instrument on board Mars Express is MARSIS, a subsurface radar sounder with a 40 meter antenna. The main objective of MARSIS is to look for water from the martian surface down to about 5 kilometers below the surface. It provides the first opportunity ever to detect liquid water directly. It is also able to characterize the surface elevation, roughness, and radar reflectivity of the planet and to study the interaction of the atmosphere and solar wind in the Red Planet's ionosphere.

In order to understand how MARSIS works it must be noted that when a radar wave encounters a boundary, as it travels from one medium into another medium, some of the energy gets reflected and some of the energy gets transmitted (Fig.1).

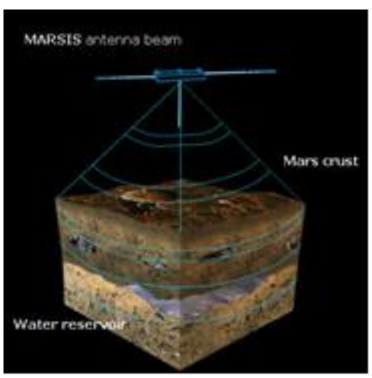

Figure 1: MARSIS operating mode

MARSIS looks for the part that gets reflected. The geologic boundary which reflected the energy might be just two different types of rock, or soil that sits on top of rock, or it might be rock that contains ice, and below that, rock that contains liquid water. Since each kind of geologic material has a certain reflectivity value, function of its dielectric constant, on the basis of analysis of the data available from the MARSIS observations, especially the surface to subsurface power ratio and the relative time delay, applying the data inversion [1, 2, 3], it is possible to estimate the materials composing the surface and the subsurface by the evaluation of their dielectric constants.

Each pulse sent to the Mars surface produces a single frame (Fig.2).

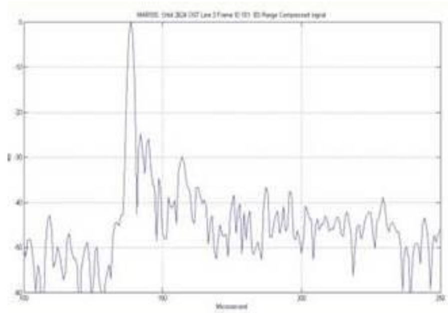

Figure 2: MARSIS frame

It consists of a first echo from the surface followed by other echos. They can be produced by subsurface interfaces like different types of rock, or rock that contains ice or large masses of ice but they can also originate from surface features as mountains, craters, hills, canyons and channels. Therefore a particular attention must be paid in the analysis of the surface morphology in order to discriminate subsurface interfaces from surface features. For every orbit, by the combination of all frames, it is build up a radargram (Fig.3) which basically is a cross-section of the planet surface. MARSIS works better on the night side of Mars because the ionosphere - the electrically charged part of the upper atmosphere - is reflective to radio waves at the frequencies that are used.

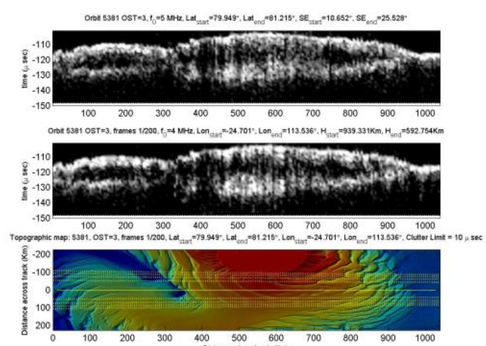

Figure 3: MARSIS radargram

Surface areas selection for radar esploration

MARSIS data quality varies considerably depending on the surface characteristics. The presence of surface features or, more generally, a high surface roughness it makes difficult, if not impossible, to identify subsurface echoes due to the high clutter generation (Fig.4).

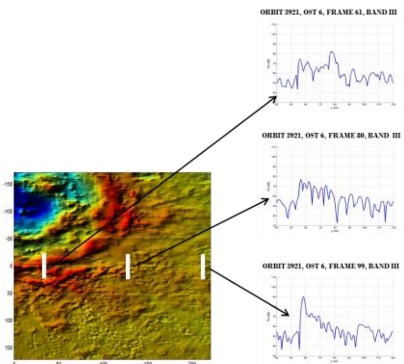

Figure 4: MARSIS data quality as a function of surface roughness

Therefore it is often convenient to perform a preliminary analysis of Mars surface in order to select smooth areas to be investigated with particular attention.

On the basis of MOLA data (Fig.5), which represent the surface altimetry, it is possible to produce slope maps with different threshold values depending on the needs of single observations (Fig.6).

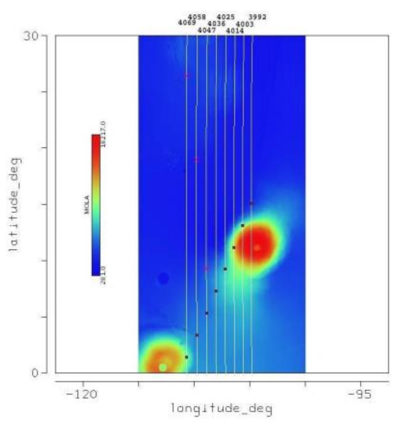

Figure 5: Mars MOLA data

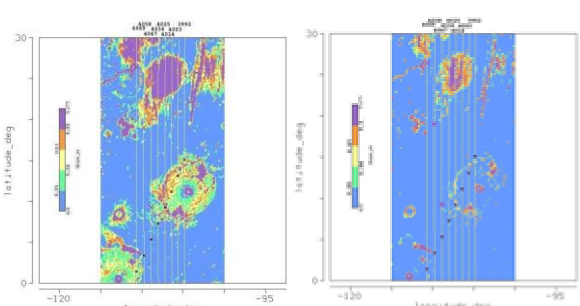

Figure 6: Mars slope data (same area) with different threshold values

In figure 6 the cyan areas are the smooth ones while the red squares represent, on Mars groundtracks, the pericenter points (closest points to the surface) of Mars express orbits, and the red crosses represent the transition from nightside to dayside. This parameter needs to be taken into account since the ionosphere, the electrically charged part of the upper atmosphere, gets excited by solar flux becoming reflective to radio waves in the frequencies used by MARSIS.

Conclusions

A preliminary analysis of Mars surface characteristics is required to estimate the expected MARSIS data quality. Features as mountains, craters, hills, canyons and channels introduce clutter effects to be taken into account. In particular the slope maps analysis has been proved to be a valuable contribution to selection of Mars areas to be deeply investigated.

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