OVERVIEW OF THE MARTIAN SUBSURFACE STRUCTURES AS SEEN BY SHARAD.
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Introduction: SHARAD (SHAllow RADar) is a subsurface sounding radar provided by ASI as a Facility Instrument to NASA's 2005 Mars Reconnaissance Orbiter for the characterization of the upper part of the Martian crust. According to the principle of operation of a subsurface radar, a pulse of electromagnetic energy, transmitted by the antenna, impinging on the top of the Mars surface produces a first reflection echo, which propagates backward to the radar. Thanks to the long wavelengths employed, a significant fraction of the electromagnetic energy is transmitted into the crust and propagates downward. Additional reflections, generated by possible subsurface discontinuities would occur and the relevant echoes would propagate backward to the radar generating further echo signals, much weaker than the front surface signal. Compared to its predecessor MARSIS [1], currently operating on board ESA's Mars Express, SHARAD is characterised by an higher carrier frequency (20 MHz vs a max of 5 MHz for MARSIS) and a much wider signal bandwidth (10 MHz vs 1 MHz of MARSIS). This allows SHARAD to achieve a finer range resolution (15 metres un-weighted in free space) at the expenses of ground penetration, which makes the instrument ideal to probe the shallow subsurface layers (up to depths of several hundreds meters) which cannot be resolved from the surface signatures by the much far-reaching MARSIS. The primary objective of the SHARAD investigation is to map, in selected locales, dielectric interfaces to depths of up to one kilometer (or more) in the Martian subsurface and to interpret these interfaces in terms of the occurrence and distribution of expected materials, including rock, regolith, water, and ice.

Investigated areas: SHARAD is operative since the beginning of the MRO Primary Science Phase, that is November, 8th 2006. The first observations were actually slightly affected by a bug in the flight software that caused a limited random error in the observation timing. However, with an additional handmade processing, the science Team has had in any case the possibility to analyse very good data mainly on both poles. A new version of the flight software has been successfully reloaded and tested at the beginning of December 2006 and the bug has been fixed. Since then SHARAD is operating fully with the nominal expected performance. All the data takes, planned since the beginning of the PSP, have been prepared taking into account the SHARAD target Data Base worked out by the science team and including, other than the poles, scientifically relevant regions of interest like, for instance Meridiani, Medusa Fossae, Hellas Planitia and Apollinaris Patera (Figure 1) and, in addition, the Phoenix proposed landing sites.

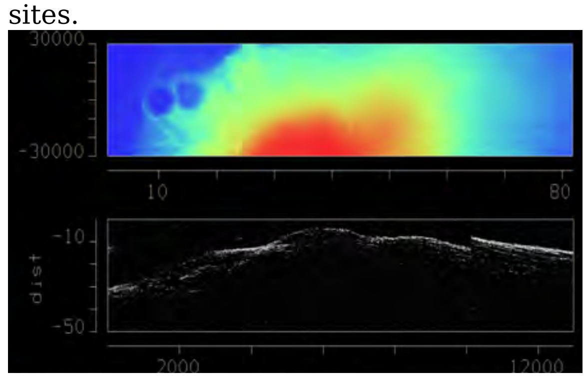

Figure 1 SHARAD data taken over Apollinaris Patera (orbit 1718). The radargram (bottom) shows subsurface features which may be due the a contact

between different rock sequences. On the top the corresponding MOLA topography.
Since the beginning of the PSP MRO has flown, at the time of this abstract (Jan 9 2007) more than 790 orbits. SHARAD has operated on 263 of them observing almost all the targets identified by the science Team, obtaining pretty good results, consistent with the MARSIS observations. A variety of interesting subsurface structures have been observed in the South Polar Layered Deposits (SPLD).

Observations over the South Pole: The south polar cap of Mars is composed by icy sediments organized in layers that present alternating albedo due to a different dust content [2]. The bulk composition is water ice, while on the top of the cap a few meters thick layer made of a mixture of carbon-dioxide and dust protect water ice deposits from sublimation.
Radargrams allow to identify subsurface features with a sufficient lateral extension to be detected by the along-track resolution of SHARAD.
Among all data acquired by SHARAD over the south pole of Mars it has been possible to identify two main type of geologic discontinuities: 1) internal layers within the SPLD and 2) a reflection coming from the contact between the SPLD with the substrate.

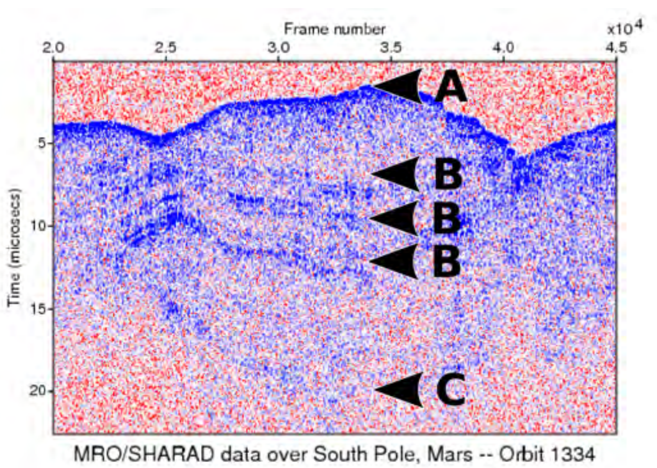

Figure 2 SHARAD radargram (top) from South Pole along orbit 1334 shows several reflections from: A) topography, B) internal SPLD layers and C) base of SPLD.

Signals form the internal SPLD layers (Figure 2, B) are less sharp and intense than the surface impulse (Figure 2, A), they are often associated with the local morphology as evidenced by the analysis of MGS/MEGDR topography [3]; they have been detected as isolated signals or in groups of several shallow reflections.
A more blurred but still easily detectable signal (Figure 2, C) occurs often with a time delay compatible with the depth of the bottom of SPLD; in the observed data, SHARAD signal penetrated up to 1400 meters of polar deposits before being reflected by the substrate.
While MEX/MARSIS data acquisition campaign is providing the overall three-dimensional shape of the SPLD, SHARAD data give us new insights on the internal organization of the polar deposits and this will turn help us to delineate a more accurate reconstruction of the geologic history of this region of Mars.

Conclusions: First SHARAD promising results show that the instrument is working properly: penetration depth occasionally gets far over a kilometer and its high vertical resolution allows us to obtain complementary data to those of MARSIS, providing a new pool of data to reconstruct the geometries and to evaluate properties of geologic features of planet Mars.

References: [1] Picardi G. et al. (2005) *Science, 310*, 1925-1928. [2] Fishbaugh, K. E. Head, J. W. (2001) *Icarus, 154,1,* 145-161 [3] Smith et al. (2003) *NASA Planetary Data System* MGS-M-MOLA-5-MEGDR-L3-V1.0.