SHARAD MAPPING OF SUBSURFACE GEOLOGIC HORIZONS IN AMAZONIS PLANITIA.

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Introduction: Amazonis Planitia has undergone stratigraphically interleaved episodes of sedimentary and volcanic infilling, with a final suite of lava flows emplaced late in the Amazonian Period. The southern part of the basin is capped by an extremely smooth deposit, a few meters in thickness, presumed to be of fluvial origin [1]. Beneath this mantling layer lies a lava flow complex whose extent is clearly defined by a high-backscatter region in Earth-based radar images [2, 3]. SHARAD radar signals reveal a subsurface dielectric interface in the south part of the basin that may correspond with the interface between mid-Amazonian basalts and the underlying sedimentary basin fill. If so, then these flows are approximately 100 m in thickness at their northern edge, and thin to 30 m or less toward the mouth of Marte Vallis.

Data: SHARAD uses a 15-25 MHz signal to penetrate hundreds of meters into dry geologic materials. The signal is swept over a range of frequencies to allow a long transmitted pulse to be compressed in time upon reception. The effective free-space vertical resolution of the received signals is about 15 m; in geologic materials this resolution improves as the inverse square root of the real dielectric constant. Most near-surface dry materials have dielectric constants of 4-6, so the vertical resolution is typically 6-8 m [4].

The horizontal footprint of the received echoes is improved in the along-track direction to about 1 km by Doppler filtering, and is a few km across track depending upon the roughness of the surface. Echoes from off-nadir surface topography (clutter) can obscure reflections from subsurface interfaces, or create spurious features that may appear to arise in the subsurface, and these are identified by creating simulated sounder echo profiles based on MOLA topography.

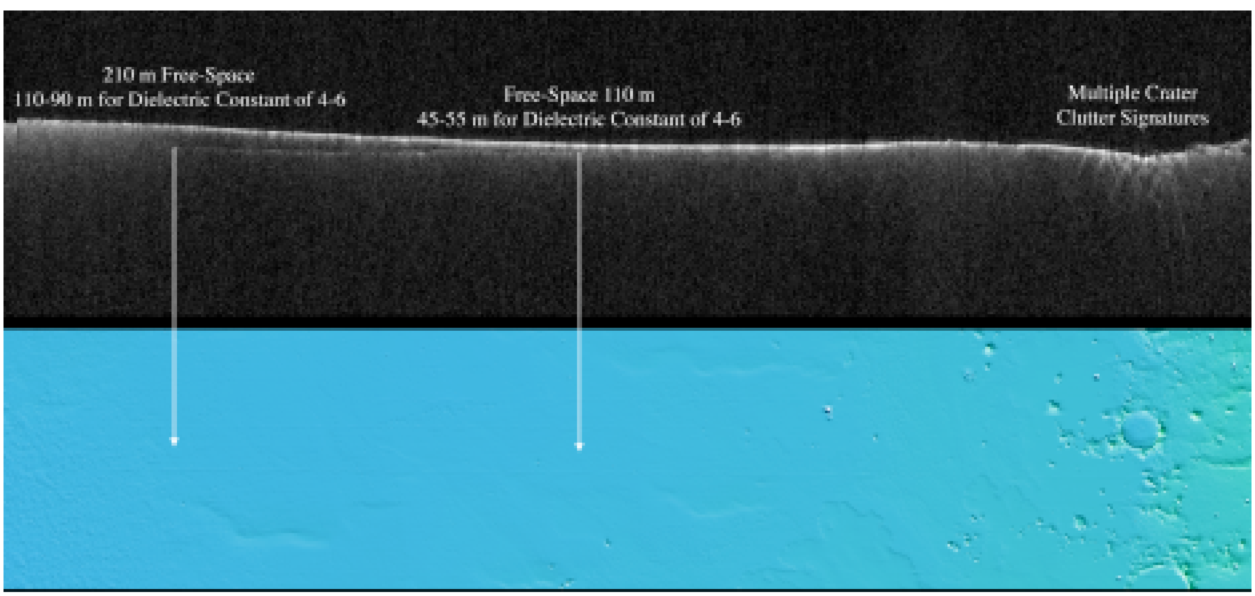

Fig. 1. SHARAD radargram for portion of orbit track 281101, with matching ground track projection of MOLA shaded-relief topography. Orbit tracks runs NE-SW (left to right), centered on longitude 195° W (Fig. 2). Arrows denote subsurface reflector beneath southern Amazonis Planitia at maximum depth of 90-110 m, shallowing to merge with the surface echo toward the south.

Amazonis Planitia Results: We have begun a campaign to acquire radar sounding profiles across all of Amazonis Planitia. A SHARAD radargram, which presents echo power versus time along the vertical axis, and traces a path along the surface with the orbit of the spacecraft, is shown in Fig. 1. This radargram shows a strong subsurface dielectric interface that begins abruptly at a depth of 90-110 m on the left, and shallows toward the right of this image until it merges with the surface echo and sidelobes. The sidelobes are a result of the signal processing that yields fine vertical resolution, but these strong artifacts may obscure echoes arising within about 30 m of the surface. It is thus possible that the subsurface horizon persists at shallow depths toward the south, but is not resolved by the sounder data.

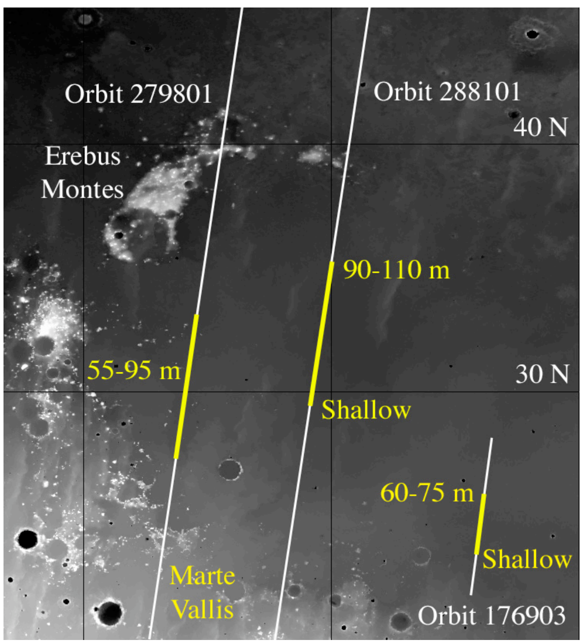

Fig. 2. MOLA topographic map of Amazonis Planitia (Lat 20-45° N, Long 180-205° W). Three SHARAD data ground tracks shown in white, with the occurrence and apparent subsurface depth of a consistent dielectric horizon noted in yellow.

Additional SHARAD tracks permit development of a regional view of this subsurface reflecting horizon. Figure 2 shows three tracks through central and southern Amazonis Planitia, with the occurrence and depth range of the reflecting horizon noted in yellow. Two of the tracks show the horizon merging with the surface return toward the south, while in the westernmost track the reflector is shallowest (perhaps 55 m) to the north and south, and up to 95 m below the surface in the center of the yellow region. In all three cases, the subsurface reflector disappears or merges with the surface return where the ground track intersects the late-Amazonian Cerberus lava flows exposed at the surface.

Preliminary Interpretations: The subsurface horizon seen across much of southern and central Amazonis Planitia must arise from a substantial dielectric contrast between geologic units. A stratigraphic analysis of this area [1] suggests the progression: (a) water and sediment discharge from Marte Vallis that resurfaced the approximately circular basin, (b) lava flows from Cerberus Fossae that flooded Marte Vallis and extended some distance into the basin, (c) a more limited discharge of water and sediments that covered the lava flows in the central basin area to depths of a few meters, and (d) late-Amazonian Cerberus lava flows that once again flowed through Marte Vallis, but extend only a short distance into the basin. Where visible at the surface, lava flow fronts of this younger unit are up to 30 m thick, and appear to thin southward toward their source vents [1]. The mid-Amazonian lava flow complex has a rough surface at the decimeter scale, as it is readily detected beneath the mantling sediment layer in Earth-based 12.6-cm radar images (Fig. 3) [3].

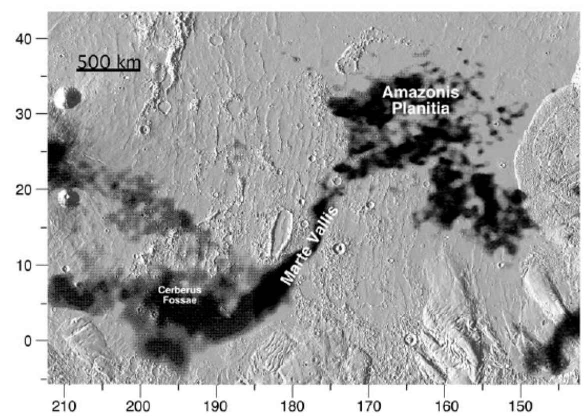

Fig. 3. Earth-based 12.6-cm radar echoes, with higher returns shown in black, overlain on MOLA data for the Amazonis Planitia/Marte Vallis region (reproduced from [1]). Much of the radar-detected flow complex in central Amazonis is mantled by a few meters of later sediments.

The subsurface reflecting horizon observed in SHARAD data is broadly correlated with the extent of mid-Amazonian flows mapped in 12.6-cm radar data (Fig. 3). This reflector appears to have an abrupt termination to the north, where it is also at greater depth (particularly in the eastern tracks). These results suggest two possible scenarios:

(1) SHARAD signals penetrate the upper mantling sediments and a mid-Amazonian lava flow complex that is ~30 m thick or less (i.e., not resolved from the surface echo), and reflect from the base of the early sedimentary basin fill.
(2) SHARAD signals penetrate the upper mantling sediments and reflect from the base of a mid-Amazonian lava flow complex that increases in thickness from ~30 m at the southern part of the basin to nearly 100 m in the central basin.

Scenario 1 requires an unlikely degree of correlation between the earlier basin fill and the mid-Amazonian lava flows noted in the 12.6-cm radar maps. The second scenario seems more likely, and is similar to the mapping of interfaces between mare basalts and regolith layers on the Moon [5]. There is, however, no MOLA evidence (Fig. 1) for abrupt 100-m scale lobes or scarps at the margins of the flow complex that was detected in this region by Earth-based radar data. The abrupt termination of the flow complex to the north may reflect ponding against pre-existing topography, with the contact now smoothed by mantling sediments.

Additional SHARAD tracks across Amazonis Planitia and nearby regions [6] will further constrain the extent and depth of the subsurface horizon, and test the hypothesis that this interface corresponds to the base of the mid-Amazonian lava flow complex.

References: [1] Fuller, E.R. and J.W. Head, J. Geophys. Res., 107, doi: 10.1029/2002JE001842, 2002; [2] Plescia, J.B., Icarus, 88, 465-490, 1990; [3] Harmon, J.K., et al., J. Geophys. Res., 104, 14065-14089, 1999; [4] Seu R. et al. (2007) J. Geophys Res., in press; [5] Peeples, W.J., et al., J. Geophys. Res., 83,3459-3468, 1978; [6] Safaeinili, A., et al., this volume, 2007.