SHARAD OBSERVATIONS OF THE MEDUSAE FOSSAE FORMATION. L. M. Carter[1], B. A. Campbell[1], T. R. Watters[1], R. Seu[2], R. J. Phillips[3], D. Biccari[2], J. W. Holt[5], C. J. Leuschen[6], J. J. Plaut[4], A. Safaeinili[4], R. Orosei[7], S. E. Smrekar[4], G. Picardi[2], N. E. Putzig[3], A. F. Egan[3], F. Bernardini[3] and The SHARAD Team, [1]Center for Earth and Planetary Studies, Smithsonian Institution, PO Box 37012, Washington, DC 20013-7012 (carterl@si.edu), [2]INFOCOM Department, University of Rome "La Sapienza", 00184 Rome, Italy, [3]McDonnell Center for the Space Sciences and the Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130 , [4]Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109, [5]Institute for Geophysics, J. A. and K. A. Jackson School of Geosciences, U. Texas, Austin, TX, [6]Center for Remote Sensing of Ice Sheets, U. Kansas, Lawrence KS, 66045, [7]Istituto di Astrofisica Spaziale e Fisica Cosmica, Istituto Nazionale di Astrofisica, 00133 Rome, Italy.

Introduction: The Medusae Fossae Formation (MFF) stretches across the Martian equator from ~140-240° E longitude and is characterized by undulating surfaces; rough, parallel grooved surfaces; and yardangs [1,2]. Exhumed and buried craters are common, and in places the formation is almost completely eroded to plains level [1,2]. The eastern portions of Medusae Fossae correspond to the radar dark "stealth" region identified in 3 and 13 cm ground-based radar images [3,4]. The unusually low radar reflectivity suggests that the near surface has a low dielectric constant, virtually no cm-scale or larger rocks, and is easily penetrable by cm-scale radar waves [3].

Medusae Fossae Formation is a geologically young deposit; it overlies both Amazonian aged lava flows in Elysium Planitia and Noachian aged cratered highlands near the dichotomy boundary [1,5,6]. Several hypotheses have been suggested for the origins of MFF, including pyroclastic flows or volcanic airfall deposits [1,3], aeolian deposits [7], or relic polar layer deposits [6,8]. These scenarios predict different deposit structures, and a better understanding of the layering and physical properties of the material will help to constrain possible formation mechanisms.

The degree of layering evident in the deposit varies from place to place. In the west, south of Elysium Planitia and west of Apollinaris Patera, the deposit is thinner, massive and there is little evidence for internal layering or differential erosion of the material [5]. Further east, layers up to 400 m thick are visible in MOLA data, and MOC images show layers that are ~50 m thick that extend across hundred-meter spatial scales [1,5].

Recently, the MARSIS (Mars Advanced Radar for Subsurface and Ionospheric Sounding) instrument on Mars Express has detected subsurface interfaces below the MFF, which are interpreted to be the basal interface between the deposit and the underlying plains [9]. MARSIS operates at frequencies between 1.3 and 5.5 MHz and has a free space vertical resolution of 150 m [10]. It can potentially penetrate a few km in depth depending on the dielectric properties of the material, but it is not useful for studying fine-scale layering or interfaces shallower then a couple hundred meters.

The SHARAD (Shallow Radar) sounding radar on Mars Reconnaissance Orbiter operates at 20 MHz and has a free-space vertical resolution of 15 m [11], which is useful for studies of near-surface layering. SHARAD radargrams over MFF can be used to look for thinner layers within the deposit and to investigate the thinner margins of the deposit where the formation is being eroded down to the plains level.

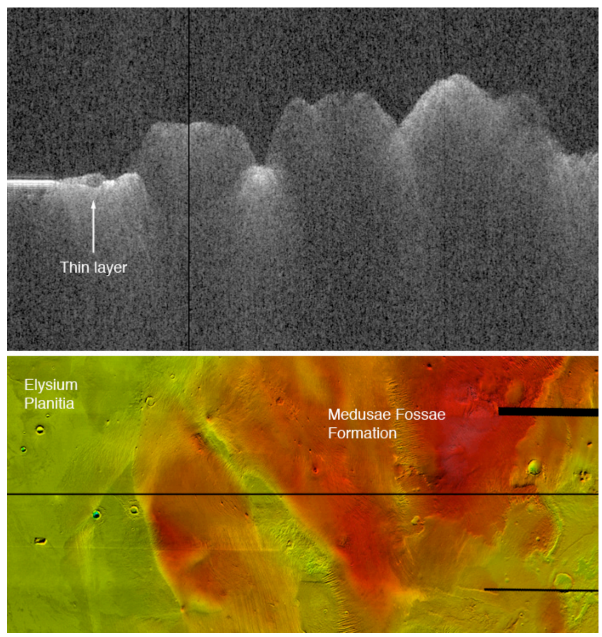

Figure 1: SHARAD radargram over part of west Medusae Fossae Formation (OBS_186301000). The radargram shows power vs. time on the vertical (delay) axis, while the horizontal axis follows the spacecraft ground track (black centerline in lower image). A thin layer can be seen with a maximum thickness of ~150 m free-space. The lower image is MOLA topography stretched to a color scale and overlaid on a THEMIS daytime IR image. The image spans ~9° of latitude at a longitude of ~152° E. The central latitude is ~1.5° N, and north is to the left.

West MFF: The western part of MFF lies just south of Elysium Planitia. SHARAD has acquired a dozen orbits over a section of the deposit located between ~150-155° E longitude. Figure 1 shows one of the radargrams that cuts through the deposit along with an image of MOLA topography overlaid onto THEMIS daytime IR images [12,13]. The THEMIS images are particularly useful for enhancing the contrast between different MFF units beyond what is observed at visible wavelengths [e.g. 14].

On the left side of the image, the plains produce a strong surface echo; these plains also have a subsurface echo component [15,16]. At the boundary between the plains and the MFF material, the radar penetrates a thin section of the deposit that is highly grooved. This thin deposit has a variable thickness, but the thickest portion has a free space depth of ~150 m (actual depth 50-100 m). As the radar moves across thicker portions of MFF material (to the right), the surface echo diminishes, and there are no strong subsurface echoes.

Figure 2 is a close up of the thin grooved unit in THEMIS daytime IR [12,13]. Exhumed craters are visible on both sides of an intervening, lower elevation plains section. Multiple SHARAD orbit tracks across this grooved unit show the subsurface interface, which allows for a detailed reconstruction of its shape and depth.

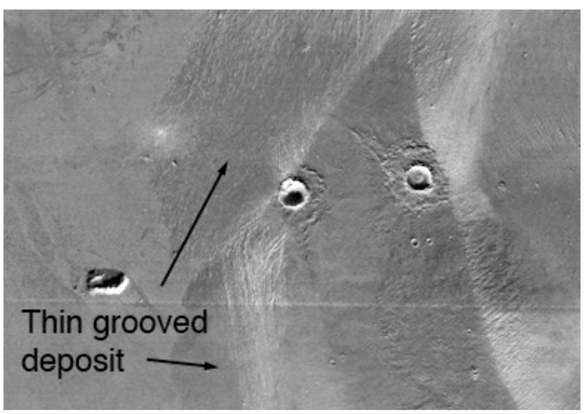

Figure 2: Close-up of the THEMIS daytime IR image [13] of the thin grooved deposit observed by the SHARAD radar.

Although SHARAD sees through portions of the MFF deposits that are ~100 m thick, it does not see strong reflections from the basal interface that MARSIS detects below the ~500 m thick outcrops of West MFF [9]. Other SHARAD orbits across this section of west MFF show subsurface reflections associated with grooved terrain on the northern boundary of the deposit, but the free-space depth is usually around ~150 m (50-100 m in unconsolidated material).

East MFF: The eastern part of MFF lies to the south and west of Olympus Mons, and includes Gordii Dorsum and Amazonis Mensa. If the deposit extends the full height of the MOLA topography relative to the plains (~3.5 km) in these areas, then SHARAD will not be able to detect a basal interface. However, SHARAD can be used to look for layering seen in MOLA and MOC images [1,5].

To date, SHARAD has only acquired data on a few orbits across the eastern part of MFF. An orbit that cuts through Gordii Dorsum at ~211° E longitude is shown in Figure 3. Where the radar crosses the extremely rough northern edge of Gordii Dorsum, the surface echo disappears almost completely. No subsurface structures can be seen beneath Gordii Dorsum or beneath Amazonis Mensa; however, a faint layer may be present in the deposits between the two higher elevation outcrops. More orbits across the area will be needed to confirm that the layer is real and not clutter from surrounding craters and ridges.

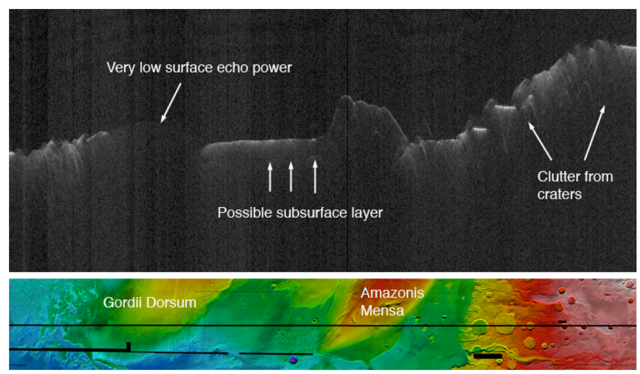

Figure 3: SHARAD radargram across part of east MFF with features marked (OBS_265201000). The lower image is MOLA topography stretched to a color scale and overlaid on THEMIS daytime IR. The image spans ~24° of latitude at a longitude of ~211° E. The central latitude is ~1° N. North is towards the left.

Yardangs are also seen to the south of Amazonis Mensa, and it has been suggested that thin layers of MFF material may cover areas outside the previously mapped area [5]. Future orbit tracks will be used to investigate the possibility of thin outcrops of MFF material in the south Tharsis area.

Summary: The SHARAD radar sees through thin deposits surrounding the Medusae Fossae Formation, but does not detect the strong basal echoes seen by MARSIS [9]. In SHARAD radargrams, the surface echoes across MFF are substantially reduced from those over plains areas, indicating that the surface appears extremely rough to the 20 MHz wave. Diffuse scattering from the surface layer decreases the transmission of power into the subsurface, and may be contributing to the lack of deep subsurface echoes.

In the western part of the formation, the radar sees through thin, grooved deposits at the boundary between MFF and the plains to the north. In the east near Tharsis, SHARAD may possibly see through material between Gordii Dorsum and Amazonis Mensa, but to date does not detect evidence of layering within the thickest parts of the deposit. Additional data currently being acquired will help to determine whether any internal layering can be seen in the eastern deposits, and can be used to search for thin layers of material on the edges of, or outside of, what is traditionally mapped as the Medusae Fossae Formation.

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