A METER-SCALE VIEW OF THE MARS RADAR "STEALTH" IN SOUTHWESTERN THARSIS.
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Introduction: "Stealth" is a region in southwestern Tharsis from which no radar signal (that can be distinguished from noise) has been returned, although the area has been probed at different wavelengths (3.5 and 12.6 cm) and phase angles [1–4]. Microwave emission at 1.35 cm have also indicated the presence of a surface that is unusual relative to the rest of Mars (*i.e.,* it has a 1.35 cm emissivity near unity) [5]. The geologic and geomorphic characteristics of the Stealth region were reviewed by Butler [3] and Edgett *et al.* [6]. The region extends for more than 2000 km along the equator west of Arsia and Pavonis Montes between longitudes 125°W and 165°W. For the past decade, the model that seemed to best explain the lack of a radar return from Stealth invoked the existence of a thick mantle of fines (grain << 1 cm). Estimates of the mantle thickness varied from a minimum of 1–3 m [1] to 1–9 m [3], and 2–15 m [4]. Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) images of surfaces within the Stealth region present a perplexing puzzle—the surfaces do not necessarily look at all like what might be expected for a meters-thick mantle.

Observations: Mantles of thickness in excess of several meters are common in Tharsis and quite obvious in MOC images with resolutions 1.5–20 m/pixel. For example, Fig. 1a and 1b show a thick, smooth-surfaced mantle in the Tharsis region. Fig. 1a shows an almost featureless surface that has broad, shallow km-scale undulations and several very small (< 100 m) superposed impact craters. The second image (Fig. 1b) shows another portion of the same mantle deposit, only here the relative thickness can be observed in outcrop form at the top of an escarpment. The debris at the base of the cliff is also mantled. The surface that lies beneath the mantle in Figs. 1a and 1b is known to be volcanic and composed of rough-surfaced lava flows, yet this roughness is not expressed at the surface because the mantle is many meters thick. The mantle in Figs. 1a and 1b looks very much like what might be assumed based upon the pre-MGS models for the nature of the Stealth region [*e.g.,* 1], but this surface does not exhibit "stealth" characteristics in Earth-based radar maps [*e.g.,* 3–4]. Figs. 2b and 2c show the location of Figs. 1a and 1b, they occur on the lower northeast flank of Pavonis Mons.

The second pair of high-resolution images in Fig. 1 (c and d) show two examples of a different surface in the Tharsis region (Fig. 1d is an expanded view of Fig. 1c). The surface here is not smooth. There are large, discontinuous ridges of the order of 50–400 m length and 20–60 m width that run diagonally from upper left to lower right. There are also fine troughs or grooves that cross these large ridges and cover much of the space between them. The fine grooves show two general trends—one set runs nearly parallel to the large ridges (upper left to lower right), the others run almost from left to right. Like the surfaces in Figs. 1a and 1b, the surfaces in Figs. 1c and 1d are also known to be underlain by lava flow material.

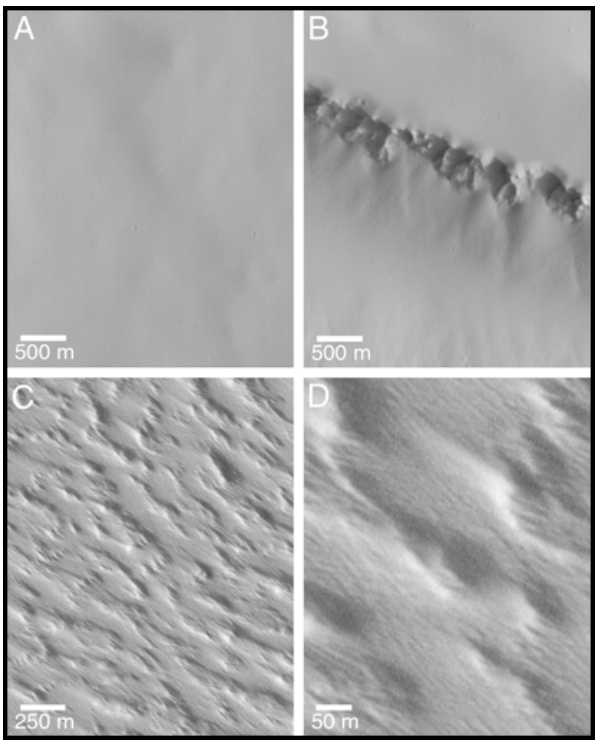

Figure 1. a) and **b)** show a smooth-surfaced, thick mantle covering lava flow surfaces in sub-frame of MOC image SP2-37703. See Fig. 2b for context. Illumination is from the lower right. **c)** and **d)** show a rough lava flow surface with a grooved covering in sub-frame of MOC image AB1-02406, illuminated from lower left. See Fig. 2a for context.

Fig. 2 shows the local and regional context of each picture in Fig. 1, and reveals that Figs. 1c and 1d are meter-scale images of surfaces within the Stealth radar region. As noted, the other two images occur on the lower NE flank of Pavonis Mons. As with the two MOC images in Figs. 1c and 1d, all other MOC images of surfaces within the radar Stealth region exhibit a grooved and rough-looking surface (*e.g.,* Fig. 3) rather than a smooth, thickly-mantled surface as in Figs. 1a and 1b.

Discussion: MOC images of the radar Stealth region do not show a surface that looks as might have been expected from the radar observations alone. Like-

wise, the thick mantle on the lower flanks of Pavonis Mons (and other thick mantles in the Tharsis region) were not anticipated by the Earth-based radar observations. The area that includes the mantle at the base of Pavonis Mons, in fact, shows radar reflectivities (more specifically, best-fit values of the reflected signal with polarization in the same circular sense as that which was transmitted to Mars) that are about the same as that of the average martian surface (see [3], Butler's Fig. 4.13 or [6] Edgett *et al.* Fig. 2). Perhaps the deep troughs that occur within the Pavonis mantle (Fig. 2b) provided sufficient radar return so as to "mask" the otherwise "stealthy' character of the thick mantle deposit, or perhaps—as the MOC image from within the Stealth region might suggest—the explanation for Stealth is simply not as well-understood as has been supposed for the past 10 years. Note when looking at Figs. 1c, 1d, and 3 that the surfaces within Stealth *are* covered by a mantle deposit. However, this mantle is quite eroded, presumably by wind, and it does not appear to be as thick as mantles seen elsewhere in Tharsis (like at Pavonis Mons in Figs. 1a, 1b). Perhaps "Stealth" owes its explanation to the grooved pattern, or perhaps not. MOC images at this point seem to indicate that the radar Stealth has no simple explanation.

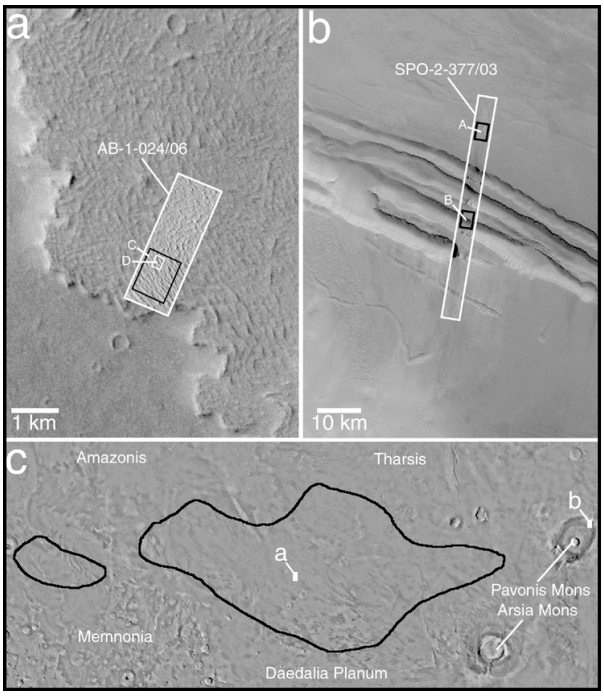

Figure 2. a) Lava flow surface in the Stealth region. Labels C and D indicate location of Fig. 1c and 1d, respectively, within MOC image AB1-02406. Context is mosaic of Viking orbiter images 731A39 and 731A41, centered near 2.7°S, 138.4°W. **b)** Troughs on lower NE flank of Pavonis Mons. Labels A and B indicate location of Fig. 1a and 1b, respectively, within MOC image SP2-37703. Context is mosaic of Viking orbiter images 090A33–36. **c)** Regional view showing locations of Figs. 2a and 2b. Dark outline indicates Stealth region as in ref. [6].

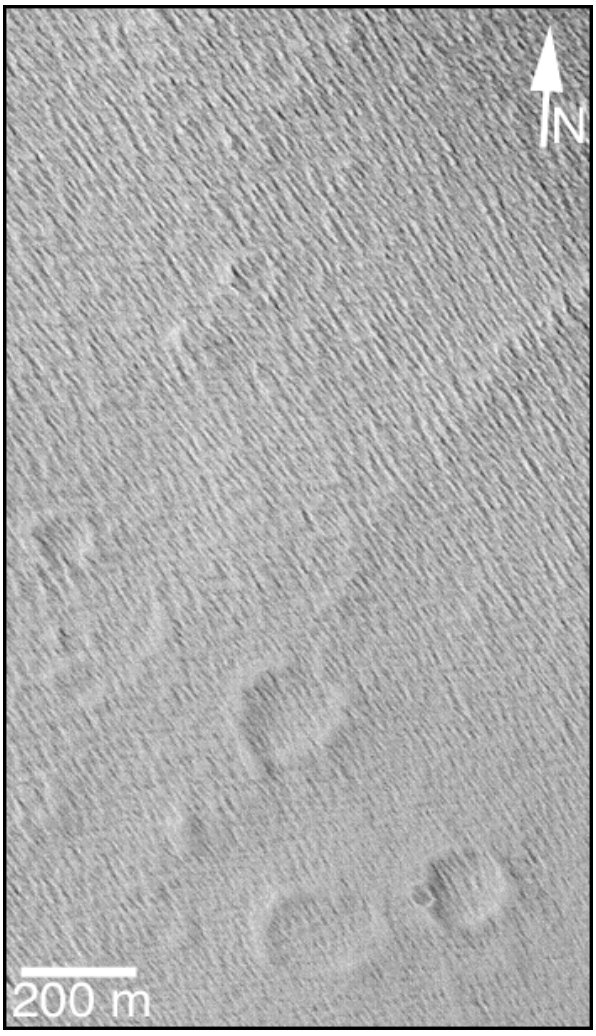

Figure 3. Another example of "Stealth" surface, shown here at full (3 m/pixel) resolution. The surface clearly is mantled, but this mantle has been eroded (presumably by wind) to form sharp ridges and grooves. Other mantles elsewhere on Mars tend to have smooth surfaces, as in Figs. 1a and 1b. Illumination is from the left. MOC image M03-00713, near 3.4°S, 133.6°W.

References: [1] Muhleman D. O. *et al.* (1991) *Science, 253*, 1508–1513. [2] Harmon J. K. *et al.* (1992) *Icarus, 98*, 240–253. [3] Butler B. J. (1994) Ph.D. Diss., Calif. Inst. Tech., Pasadena. [4] Muhleman D. O. *et al.* (1995) *Ann. Rev. Earth Planet. Sci., 23,* 337–374. [5] Ivanov A. B. *et al.* (1998) *Icarus, 133*, 163–173. [6] Edgett K. S. *et al.* (1997) *JGR, 102*, 21545–21567.