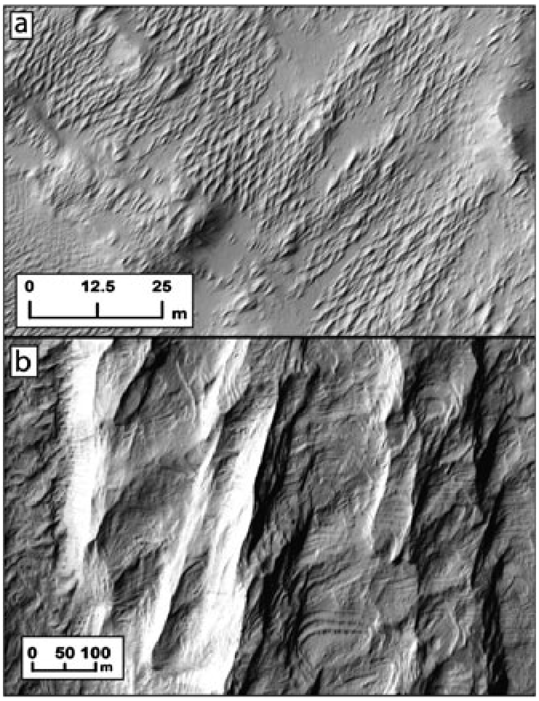


**Figure 14.** End-member terrains. a) Bidirectional yardangs, which could be formed from the erosion of indurated network TARs (portion of HiRISE image PSP_007763_1805). (b) Swirling, discontinuous layers in a yardang, possibly indicative of the variable dip of bedding typical of an aeolianite (portion of HiRISE image PSP_009464_1695).

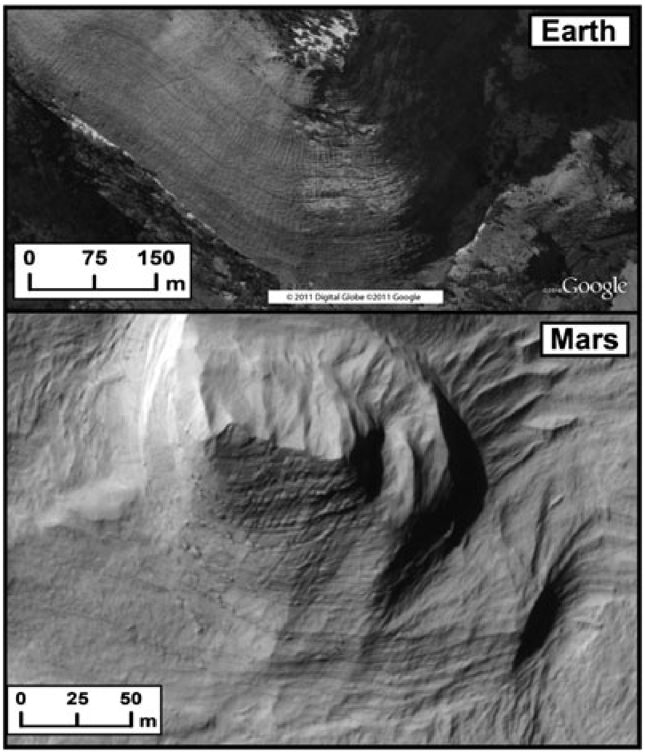


**Figure 15.** A comparison of (a) the Navajo Sandstone in Utah, USA with (b) an MFF yardang face on Mars. Note subtle layering and jointing in both cases. (a) Digital Globe image from Google Earth, image catalog number 101001000407DA02, taken 02/04/05, lat: 37.22 N, lon: 112.89 W. (b) Portion of HiRISE image ESP_017534_1690.

hypothesized to exist on Mars. The coarse-grained ripples studied by the Spirit Rover were described as covered in dust and having a crust (Sullivan *et al.*, 2008). Dust could inhibit movement of coarse-grained ripples because it is less easy to loft than slightly larger particle-sizes (Bagnold, 1941; Greeley and Iversen, 1985). Chemical cements such as calcrete, silcrete, alcrete, gypcrete, ferricrete, or sulfate compounds have been suggested as the means of induration at work in inverted terrain on Mars (Pain *et al.*, 2007). These types of cementing agents are commonly found in duricrusts in the tropical and arid zones of Earth (Desen and Peterson, 1992) and could also be a means of indurating the MFF TARs. It has been proposed that sedimentary silica could be important on Mars, weathering from the non-quartz portions of basaltic rocks or from volcanic glass (McLennan, 2003). Further orbital and surface exploration and analysis of the MFF is necessary to identify the most likely candidate induration processes and materials.

Whether they are long-wavelength ripples or transverse dunes, TARs are most likely composed of either sand-sized particles (0.062.5–2 mm) or coarse granules (2–4 mm) (Wentworth, 1922). The presence of yardangs suggests that the sand-sized or granule particles must be coherent and durable enough to abrade at least the yardang troughs. The presence of TARs thus implies that the MFF is made up of a significant portion of sand or granule particles. Large quantities of sand would suggest a proximal source for major components of the MFF, as sand cannot be transported as far from its source as dust can.

## Conclusions

Numerous indurated and eroded transverse and networked aeolian ridges have been documented within the equatorial Medusae Fossae Formation. Cratered dunes and TARs are seldom seen elsewhere on Mars, an observation that we interpret to mean that these particular TAR-like bedforms in the MFF have been inactive for much longer than TARs and dunes found elsewhere. The presence of indurated and eroded bedforms in the MFF supports the hypothesis that the Medusae Fossae has undergone multiple cycles of erosion. This hypothesis suggests that a large part of the MFF in its present configuration is likely to be composed of secondary and tertiary deposits derived from erosion, reworking and redeposition of the MFF. This interpretation is consistent with the many ambiguous stratigraphic relationships found within the MFF that suggest erosion and reworking (Kerber and Head, 2010). This hypothesis is also consistent with the wide variety of deposit and feature morphologies present in the MFF and the tendency for one type of terrain to grade into another (for example, small changes in wind regime and particle availability could make the difference between a sea of network TARs, 'faceted' terrain, and bidirectional yardang terrain). In this context, the age of any particular region of the MFF would reflect only its particular stage in the recycling process, rather than its absolute age of emplacement. The young Amazonian crater age of the MFF (Scott and Tanaka, 1986; Greeley and Guest, 1987; Werner, 2006) is thus interpreted to be a crater retention age (Schultz and Lutz, 1988; Schultz, 2002; Kerber and Head, 2010) rather than a formation or original emplacement age. Evidence from MFF stratigraphic relationships with Hesperian-aged lava flows (Kerber and Head, 2010) suggest instead that the formation age of the MFF is at least as old as Hesperian (a period lasting between 3.5 Ga and 3.4 to 2.0 Ga; Hartmann and Neukum, 2001).

Fundamentally, the use of morphological and stratigraphic clues to determine the formation mechanism of the MFF depends on the assumption that these traits are related to the primary emplacement of the formation. For example, the presence of MFF material stratigraphically above a given lava surface implies that the MFF was deposited there after the lava cooled, but it does not necessarily guarantee that it was

 