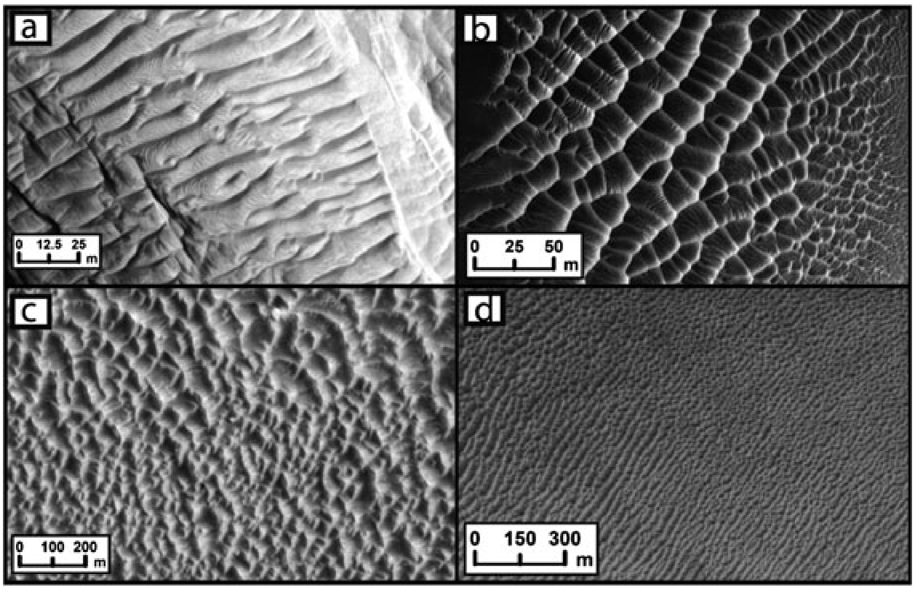

Figure 4. Typical transverse aeolian ridges. (a) Linear, forked TARs. Note sharp ridge crests and crisp secondary bedforms (bright, linear features aligned perpendicular to ridge crests). (b) Networked TARs at the bottom of Victoria Crater. Sharp crests and crisp secondary bedforms are also apparent here. (c) Type example of 'barchan-like' TARs, as identified by Balme *et al.* (2008). (d) Example of networked TARs grading into linear TARs, featured in Balme *et al.* (2008). Portions of HiRISE images (a) PSP_006879_1915 and (b) ESP_011765_1780, and MOC images (c) M1800277 and (d) R0902119.

Ward (1979), who observed that sediment formed transverse wind forms between MFF yardangs and hypothesized that they could be coarse-grained ripples, in analogy to coarse-grained ripples which are often seen in inter-yardang troughs on Earth. TARs found in the equatorial region of Mars appear to be most numerous in close proximity to fine-grained layered deposits, suggesting that these deposits may represent a source for TAR-forming material (Berman *et al.*, 2011)

Yardangs

Yardangs are wind-sculpted erosional ridges that occur in deserts on the Earth and Mars (Hedin, 1903; Ward, 1979; Figures 5 and 6). They are always oriented sub-parallel to prevailing winds, with a blunt head facing upwind and a long, aerodynamically tapered tail pointing downwind (Ward and Greeley, 1984). The shape of an individual yardang has often been compared to the inverted hull of a ship, leading groups of yardangs to become known as 'fleets' (Bosworth, 1922).

Yardangs appear to be formed through a combination of aeolian abrasion (bombardment with saltating, sand-sized particles) and deflation (the plucking of grains by the wind) (Ward and Greeley, 1984). Abrasion is thought to be important at the headward end of the yardang, especially in places where the head is undercut at the height of most intense saltation, and in the valleys between yardangs, which are slowly broadened and deepened over time (Ward, 1979; Breed *et al.*, 1989). Deflation appears to be important in maintaining the aerodynamic tail of the yardang (Breed *et al.*, 1989). Fluting and vortex pits are often observed on the flanks of terrestrial yardangs, indicating that fine sediment suspended in complex, turbulent flows can also play a role in yardang erosion (Whitney, 1983, 1985). These flutes can be anywhere from 5 to 60 cm wide and up to several meters long (Breed *et al.*, 1989).

On Earth, yardangs form at several scales and in a variety of substrates, including sandstones, siltstones, heavily eroded crystalline basement rocks, and ignimbrites (McCauley *et al.*, 1977). Several fleets of a larger form of terrestrial yardang, termed 'mega-yardangs' are shown in Figure 5 (Goudie, 2007). Yardangs up to 60–80 m in height with rounded heads are found in the Lut Desert of Iran, carved into silty clays and gypsiferous sands (Goudie, 2007; Figure 5(a)). The morphology of these yardangs is modified by periodic rains which incise gullies into the flanks of the yardangs. Yardangs in the Borkou region of Chad are among the largest on Earth (up to a kilometer across) (Goudie, 2007; Figure 5(b)). These yardangs are eroded into highly lithified sandstones (Livingstone and Warren, 1996). Yardangs of the Peruvian coastal desert are carved into horizontally bedded siltstone, creating yardangs with obvious layering (Bosworth, 1922; Figure 5(c)). The morphology of an individual yardang is affected by its lithology, the availability of sand-sized particles to cause erosion, the local wind regime, and the presence of non-aeolian processes such as rain.

Martian yardangs are generally larger than yardangs on Earth (which can be meters across), but are similar in dimension to terrestrial mega-yardangs (hundreds of meters to a kilometer across) (Figure 5). Like mega-yardangs, Martian yardangs also tend to be longer in the direction parallel to the wind, up to tens of kilometers. They are found dominantly within the MFF, although yardangs are also present in the Arabia Terra region of Mars and in several outlying friable deposits (Malin and Edgett, 2000). Here we discuss only yardangs found in the MFF; these display many diverse morphologies (Figure 6).

The yardangs in the Apollinaris Sulci region of the MFF have smooth, bulbous, concave heads (Figure 6(a)). They are similar in size and shape to the Borkou yardangs (Figure 5(b)), although Martian yardangs are commonly more pointed on their upwind sides than terrestrial yardangs, which usually have rounded heads (Figure 5). In the Zephyria region of the western MFF the yardangs are more equant in shape (Figure 6(b)). These yardangs approach the 'ideal' width-to-length ratio of 1:4 needed to minimize the force of drag over the body (as documented by Ward and Greeley, 1984). These yardangs have what is called a 'keel': a medial ridge that resembles the keel of a boat. Laboratory studies have indicated that a layered substrate with a hard layer overlying a soft layer can lead to the development of keels (McCauley *et al.*, 1977, 1979), perhaps indicating that some of the western MFF yardangs once had a

