CONTROLS ON THE MORPHOLOGY OF YARDANGS ON THE EARTH AND MARS L. Kerber[1] [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109 (kerber@jpl.nasa.gov).

Introduction: Yardangs are wind-eroded ridges common in regions of Mars [1] and in the most arid deserts on Earth. Yardangs have also been documented on both Venus [2] and Titan [3]. Throughout the years, studies of yardangs have concentrated on particular field sites, and therefore conclusions relating to the controlling parameters on yardang morphology have been highly divergent.

Many variables affect yardang morphology:

(1) *Deflation vs. Abrasion*. The wind erodes yardangs both through the abrasion of the yardang head as well as deflation of the yardang flanks. A long-standing debate within the yardang literature is the relative importance of the two processes. For the Rogers Lake yardangs, [4] argued that abrasion of the yardang head, augmented by periodic collapse of the undercut yardang head, was the main driver of erosion, while [5] argued that deflation was the main morphological driver. A recent visit to the yardangs by the author helped to shed light upon this controversy. We revisited one of the yardangs at Rogers Lake that was originally photographed by [6] in 1932, and then again by [4] in 1975 (Fig. 1) Between 1932 and 1975, abrasion of the yardang head is obvious, with the development of an undercut face, supporting the hypothesis of [4]. However, between 1932 and 2015, the most dramatic change is the complete disappearance of the flank of the background yardang. The erosion of this flank, outside of the path of yardang abrasion, argues for a large role for deflation, supporting the hypothesis of [5]. Deep gullies can also be seen on the flanks of the Rogers Lake yardangs (Fig. 1), arguing for a large role for pluvial processes in yardang denudation.

(2) *Ridges vs. Troughs*. Some yardang fleets are defined by a largely flat plane interrupted by wind-shaped ridges, while other fleets are defined by un-shaped remnant topographic highs interrupted by long, straight troughs filled with sand. In the latter case, it is the presence of the troughs which channel the sand and create the illusion of defined ridges from above.

(3) *Pre-existing Shapes vs. Wind-formed shapes*. While many yardangs owe their major relief to the wind, others are simply pre-existing knobs and mesas that have been modified by the wind.

(4) *Isolated vs. Interfering*. Widely space yardangs achieve a more "perfectly streamlined" appearance than closely spaced yardangs, which cause interference in the incoming wind profile.

(5) *Burial vs. Erosion*. The level of current activity of a yardang fleet is partially controlled by the availability of sediment compared to the wind's ability to move it [7].

(6) *Isotropic Substrate vs. Layered Substrate vs. Fractured Substrate*. Isotropic substrates lead to smooth yardang flanks and evenly spaced yardangs. Strings of yardangs can nucleate along substrate fractures, and fractures can speed yardang erosion through mass wasting. Layered substrates can yield flat-topped "layer-cake" yardangs, and differential erosion of the layers can enhance gravity-driven mass wasting.

(7) *Original flank texture vs. Water-Dominated Texture vs. Wind-Dominated Texture*. In many yardangs original lacustrine bedding and/or aeolian cross-bedding can be seen. In others, a patina of water-deposited clay flakes or a carapace of salt-cement is seen. In the windiest, driest places, yardang flanks are dominated by aeolian fluting.

(8) *Water erosion vs. Wind Erosion vs. Mass Wasting*. Many terrestrial yardangs flanks are heavily modified by pluvial gullying. Martian and extremely arid terrestrial yardangs are dominated by aeolian faceting.

(9) *Constant Winds vs. Changing Winds*. Yardangs need mostly unidirectional winds to form, but bidirectional winds or slightly shifting winds can create different yardang morphologies.

Fig 1. Evolution of a yardang over 83 years. Note undercutting of foreground yardang in 1975 and missing yardang flank between 1932 and 2015 (red arrows). The interyardang troughs have been filled in by a significant amount of sand since 1975.

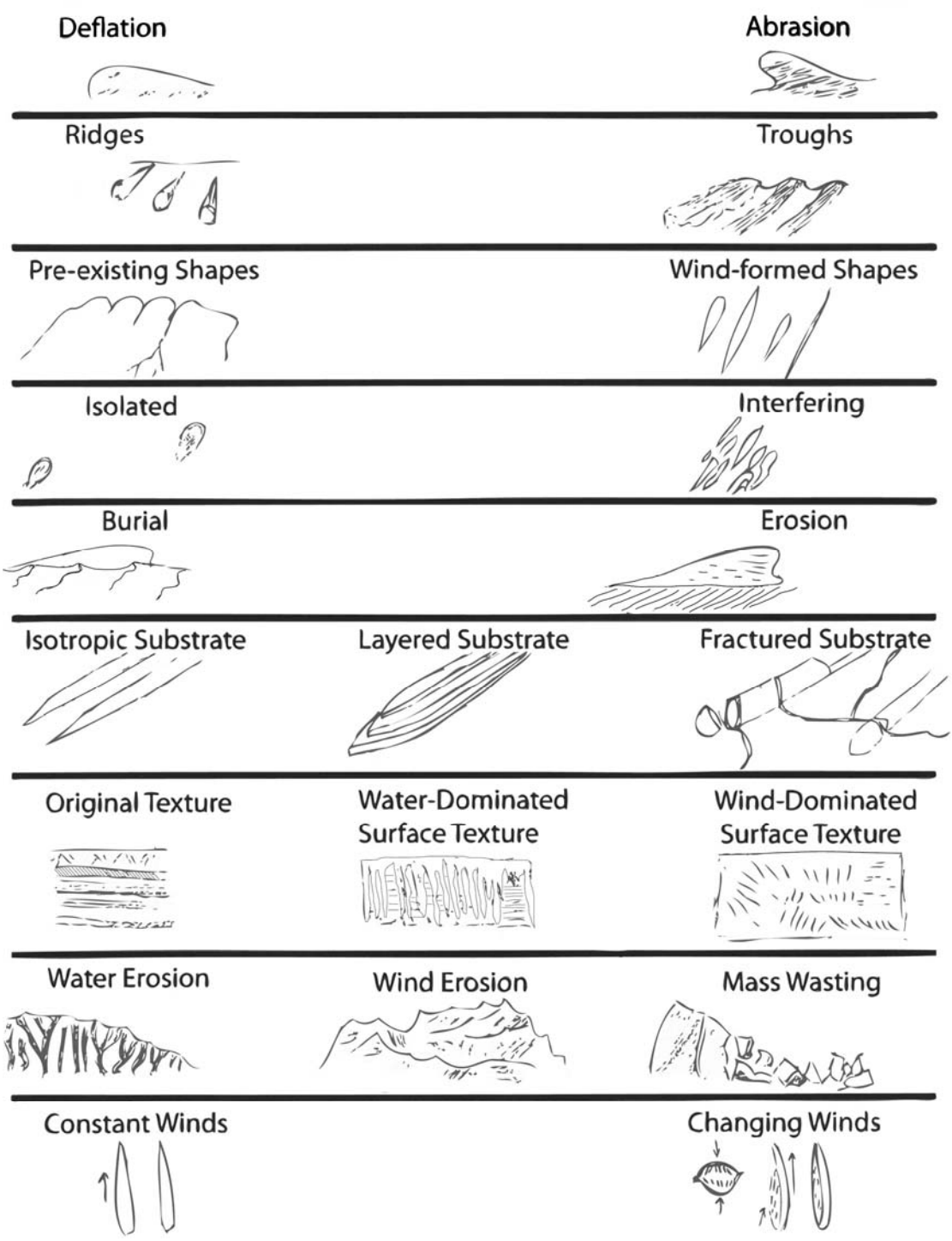

Fig. 2. Controls on yardang morphology on Earth and Mars.

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