

VARIETIES OF BARCHAN FORM IN THE NAMIB DESERT AND ON MARS. Andrew S. Goudie¹ and Mary C Bourke². ¹Saint Cross College, Oxford. andrew.goudie@stxox.ac.uk ²Planetary Science Institute, Tucson, Arizona, 85719 mbourke@psi.edu

Introduction: Barchans are individual, mobile, crescentic shape dunes, the two horns of which face in the direction of movement. Generally they occur in areas of limited sand supply, with a low precipitation and vegetation cover, on planar surfaces and where winds are unimodal to narrowly bimodal. On Mars, the most common dune is transverse and within the barchan group there is a wide variety of forms [1] (Fig. 1).

Morphological classifications: There is little work that describes or explains the morphological variety of barchans. One useful hierarchical classification considers barchans as simple, compound or complex [2]. Another attributes barchan form to a stage in dune evolution [e.g., barchanic shield dune, 3]. Long and Sharp [4] use a ratio between the length of the windward slope (a) and the horn to horn width (c) to categorize barchans: Fat (≥ 1), Pudgy (0.75) Normal (0.5) and Slim (0.25). This classification may be useful for Martian dunes and give insight into the controls on dune form.

Barchan shape is a function of grain size, wind flow velocity, sand saturation, and wind variability [5]. For example, a smaller grain size or higher wind speed both produce a steeper and blunter stoss-side. A low saturation of the interdune sandflow produces an open crescent-moon shaped dune [5]. Dunes in areas characterized by coarse sediment (higher effective wind threshold) and/or low speeds may have lower, longer profiles compared with those in areas with fine sediments and/or strong winds [6]. Dune shape is not necessarily scale invariant. The windward profile has been found to be nearly a straight line for tall dunes, but becomes increasingly convex for smaller ones [7, 8]. Equally, the relative position of the slip face within the whole dune varies with dune size, but also the ratio of horn length to total length increases with the height [9-11].

A satellite image survey of the Namib Desert found that there was a wide range of barchan morphologies present that are more varied and complex than is often assumed. The purpose of this paper is to report on those findings and to present similar forms found on Mars.

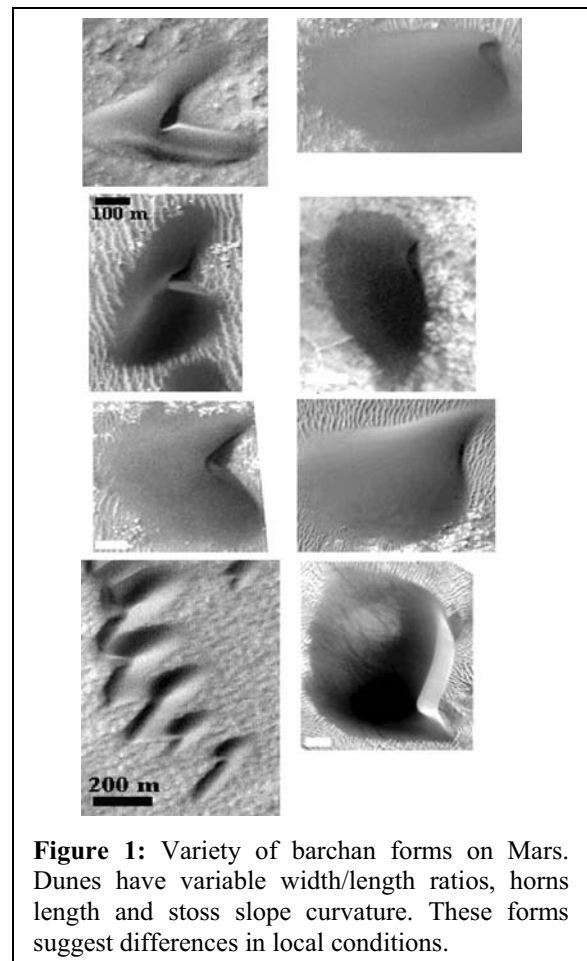


Figure 1: Variety of barchan forms on Mars. Dunes have variable width/length ratios, horns length and stoss slope curvature. These forms suggest differences in local conditions.

Type 1: Classical symmetrical barchans-Normal & Slim: The simplest form of barchan is the classic individual crescentic feature. Some of these are elegantly slim (Fig.2a) found on the rocky plains to the south and east of Luderitz and Elizabeth Bay. They also appear to be rather angular in plan. They display a wide range of sizes, with some having widths as great as 500-600 m, and some only a few tens of metres. These are a feature of areas with unidirectional winds, low sand influx and high values for shear velocity [12]. The examples in southern Namibia occur on rock surfaces that have a very limited sand cover, and because of their proximity to the coast have high wind velocities from a relatively constant direction with a total annual sand flow potential that exceeds 1200 tonnes/m/yr. As a

consequence rates of barchan migration are particularly high [13].

Slim barchans, are also found on Mars (Fig. 3a). Dunes that most closely resembled a classic crescentic shape were preferentially selected in a study of barchans [1]. As expected, all barchans surveyed are in the 'Slim' category. However, the north polar barchans were slimmer ($a/c = 0.37$) than the inter-crater dunes ($a/c = 0.52$). The example shown (Fig. 3a) is extraordinarily 'slim' ($a/c = 0.17$) and similar values have not been reported from surveys on Earth.

Type 2: Classic symmetrical barchans – Pudgy & Fat: Dunes in this class have horns that are relatively small in relation to the total mass of the dune (Fig. 2b). Fat dunes occur in areas where there is a substantial sand influx and lower shear velocity [12]. Many of the world's barchans described in the literature appear to be fat and pudgy rather than slim. On Mars dune fields of Pudgy and Fat barchans are found in the north polar region, particularly on the margins of large dune fields and in locations where the topography may concentrate windflow (Fig. 3c). This may indicate a higher (local) sediment supply and lower shear velocity. This is also suggested by changes observed in dome dunes [14].

Type 3: Classic symmetrical barchans – large, fat and unstable: Mega-barchans (>500 m wide) often have secondary features on their flanks, which may be indicative of instability. They often shed small barchans downwind (Fig. 2c). Megabarchans are also found on Mars. They are larger than those in Namibia and have simple, rather than complex or compound forms [15].

Type 4: Classic symmetrical barchans composed of smaller barchans. One remarkable barchan was identified in southern Namibia. It is a classic barchan form some 400 m across and 700 m long that is predominantly made up of a cluster of smaller barchans. It may be an extreme form of the Type 3 barchan and an example of proto-mega-barchans [16]. A similar form has not yet been detected on Mars although there are examples of degraded and modified barchans that may, in time, approach this morphology.

Other barchan dune assemblages were noted in Namibia but are not explored in this abstract. They include, *Type 5:* asymmetrical barchans

that form linear dunes; *Type 6:* coalescing barchans that form transverse ridges; *Type 7:* barchan convoys that form linear ridges.

Application to Mars: Although useful, there remains a large variability of barchan forms on Mars that is not adequately differentiated by this approach. Other morphometric ratios may be more appropriate and are being explored.

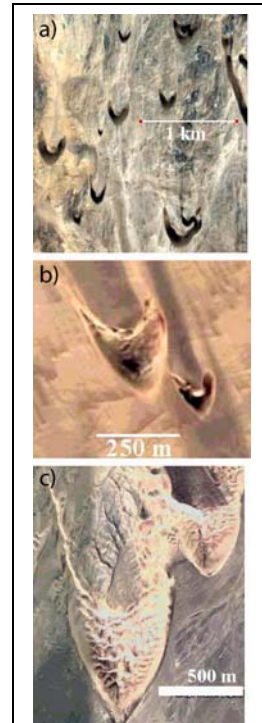


Figure 2 Barchan dunes in Namibia
a) Normal (0.5)
b) Pudgy (0.74)
c) Fat (0.99)

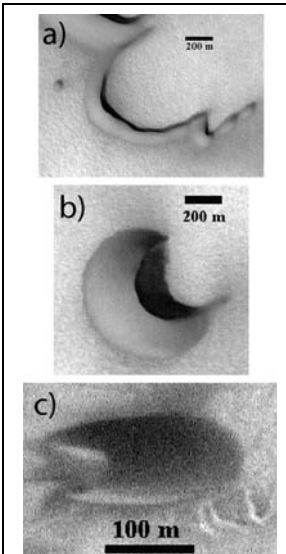


Figure 3 Examples of dune shapes on Mars according to the classification of Long and Sharp (1964).

- a) Slim (0.17)
b) Pudgy (0.67)
c) Fat (2.43)

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