The implications of symmetric and asymmetric barchans on Mars

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Barchans, the most dominant dune type on Mars, have many different shapes both symmetric and asymmetric. Most barchans are known to be asymmetric, with one horn different than the other. The active barchans of Nili Patera and Noachis Terra, for example, have several varieties of symmetric and asymmetric shapes.

The first two models of asymmetrical barchans presented in the literature (Bagnold 1941; Tsoar 1984), which were based on field observations and measurements, explained the transition of barchans into linear seif dunes. These two models pertained to the effect of two main wind directions, where one of them, the stronger one, was the primary transport wind direction. These two models do not explain all types of barchan asymmetry.

Not every asymmetric barchan may undergo a transition to a longitudinal (seif) dune under a bimodal wind regime. Our barchan dune modeling shows that a bimodal wind regime causes horn extension to evolve into a seif dune when the divergence angle between primary and secondary winds is larger than 90^{o}, and the ratio between the secondary and primary transport rates is > 25%. Other reasons for an asymmetrical barchan with extended horn are an inclined surface under constant wind direction and a tilted surface that causes the horn to move laterally, with transverse migration velocity proportional to the slope of the terrain. Horn elongation induced by topography can occur when a barchan crosses a topographic rise. Furthermore, transient asymmetric barchan shapes with an extended horn also emerge during collisions between dunes or due to an asymmetric influx of sand. However, no seif dune is obtained from all these occurrences.

Moreover, numerical simulations (Parteli et al. 2014; Lv et al. 2016) have shown that acute bimodal winds also lead to the elongation of the same barchan horn, but the asymmetric barchan shape is stable and this horn does not keep elongating to form a seif dune.

References

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