INTERNAL STRUCTURE OF MOBILE BARCHAN SAND DUNES

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In this work, we visualize the internal structure of mobile barchan desert dunes at the avalanche scale. We reveal an intriguing history of dune building using a novel combination of local sand sampling and advanced geophysical techniques resulting in high resolution measurements of individual avalanche events.

We present scientific data on the structure obtained from two mobile barchan dunes during recent desert field campaigns (2014, 2015) in Qatar. The area at 25.01°N, 51.34°E in the Al Wakrah municipality in the Umm Said desert near Doha, Qatar, has been equipped with a weather station and has been regularly visited by a multidisciplinary research team in recent years (e.g. [1]). The two barchan dunes have distinct dimensions, the larger dune rises to $h \sim 28 \pm 2m$ while the smaller dune reaches $h \sim 5.0 \pm 0.5m$; mass conservation [2] ensures the dunes move at different migration speeds, $V \sim 5.1 \pm 0.3m$ versus $V \sim 18.4 \pm 0.1m$ respectively.

Due to progressive rebuilding and erosional and depositional processes, these marching barchan dunes are reworked every few years and a characteristic zebra-pattern, orientated parallel to the slipface, is apparent at regular intervals as illustrated in figure 1a.

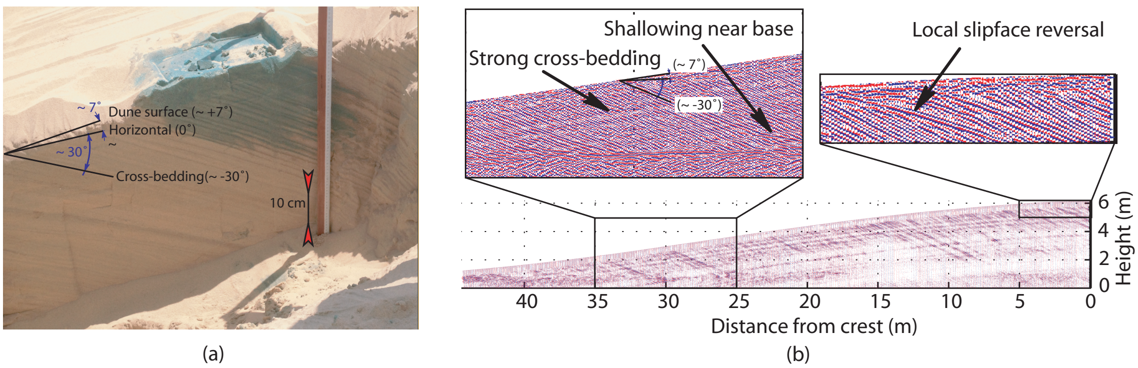

Figure 1. (a) Characteristic zebra-pattern on a midline cross-section of a mobile barchan dune, (b) typical continuous Ground Penetrating Radar profile across the midline.

The dune stratigraphy, exposed by a few sandpits, reveals regular cross-bedding inclined at the angle of repose ($\sim 30°$). By applying high-frequency (1200 MHz) ground penetrating radar (GPR) transects across the midline, as illustrated in figure 1b, we map the continuous evolution of this cross-bedding deep within the dune. The GPR also reveals a slope reduction of the slipface near the base of the dune; evidence of irregular wind reversals; and the presence of a harder aeolian cap around the crest and extending to the brink. The data is supplemented with granulometry from layers stabilized by dyed water injection and uncovered by excavating vertical walls perpendicular to old buried avalanches. We attribute visible differences in water penetration between adjacent layers to fine particle segregation processes in granular avalanches.

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References

[1] Louge, M. Y., A. Valance, A. Ould el-Moctar, J. Xu, A. G. Hay, and R. Richer, *Temperature and humidity within a mobile barchan sand dune, implications for microbial survival*, J. Geophys. Res. **118**, doi:10.1002/2013JF002839 (2013).

[2] Bagnold, R. A., *The Physics of Blown Sand and Desert Dunes*, Methuen, London (1941).