DUNE FORMATION

by Marina Coetzee

The wind speed and size, density and shape of minerals determine how transported material is winnowed and sorted. Aeolian (wind-borne) deposits are rather uniform in terms of grain size.

Wind transports weathered material in three ways: suspension, saltation and surface creep: The finest particles – silt and clay – are *suspended* when blown high into the air. Silt-sized dust remains aloft over long distances and fine, plate-shaped clay minerals and micas stay suspended even longer. Nutrients in dust from sandstorms over the Namib fertilise the Southern Atlantic. Namib soils contain less silt and clay than the Sahara, so severe dust storms are less frequent and intense. The heaviest mineral particles – pebbles, coarse gravel, heavy minerals, coarse sand grains – are pushed and rolled along the surface in a process known as *surface creep*. Creep accounts for about 4% of a sand grain's movement. Fine gravel and sand are bounced along by a process known as *saltation*. Saltation accounts for about 96% of a sand grain's movement. It is initiated by small differences in air pressure caused by tiny irregularities of the surface – the Bernoulli effect. Every grain that lands knocks more grains into the air. As more sand grains become airborne on the stoss (upwind) side of the small irregularities and deposition happens on the lee side that is slightly more protected from the wind, self-organised ripples develop perpendicular to the wind direction. The average distance a grain bounces is the width between the crests of two sand ripples.

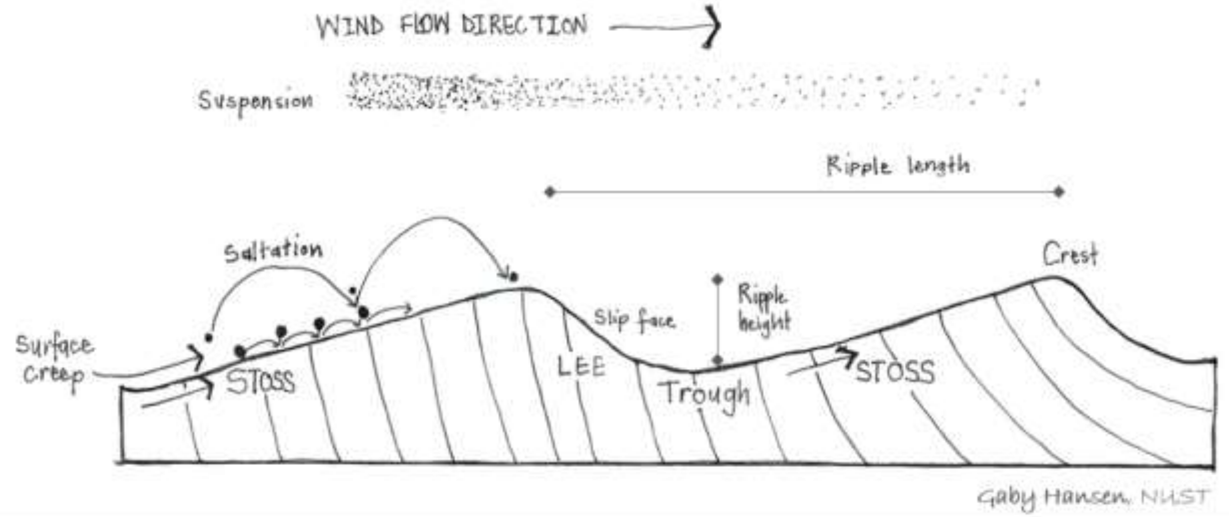

Figure 1. Dune formation *(Gaby Hansen)*

Dunes form in a similar process, on a larger scale. Transported sand settles as a sand patch in the lee (downwind side) of an obstacle (vegetation, rock, sand ripple) and grows in size. The transport capacity of wind decreases as it drives sand grains up the windward side of the growing dune, causing sand to be deposited before reaching the dune crest. As the dune grows, the lee slope steepens until it exceeds the 'angle of repose', which is 32-34^{o} for dry sand. Gravity overwhelms the shear strength of the sand and it avalanches down the lee side, forming a slip face. Over time, the dune migrates downwind by deflation of the windward side and deposition on the lee side.

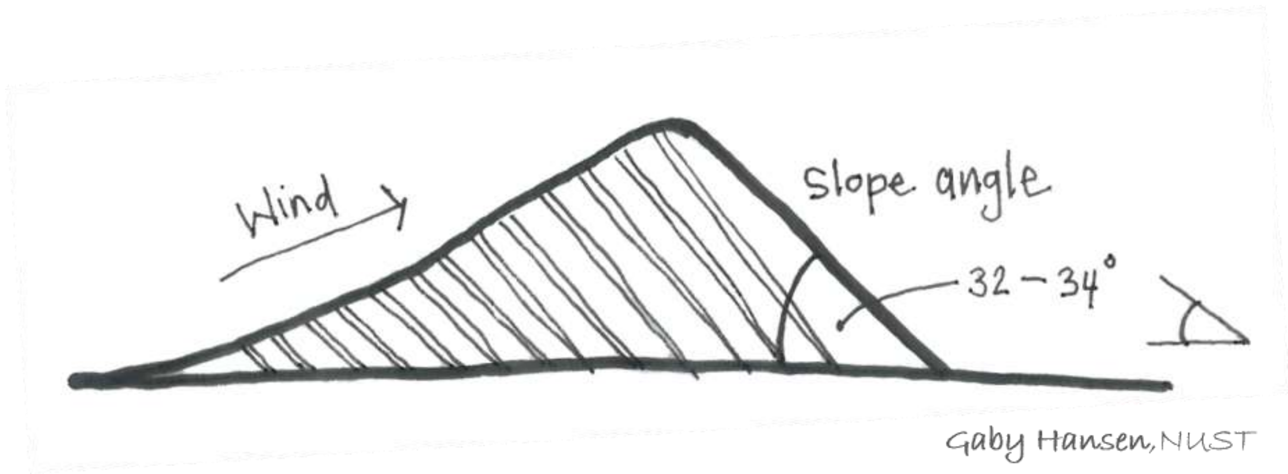

Figure 2. Angle of repose *(Gaby Hansen)*

Smaller particles blown across the dune crest tend to travel farther than large ones. The result is that aeolian sand deposits show a coarsening-upward sequence.

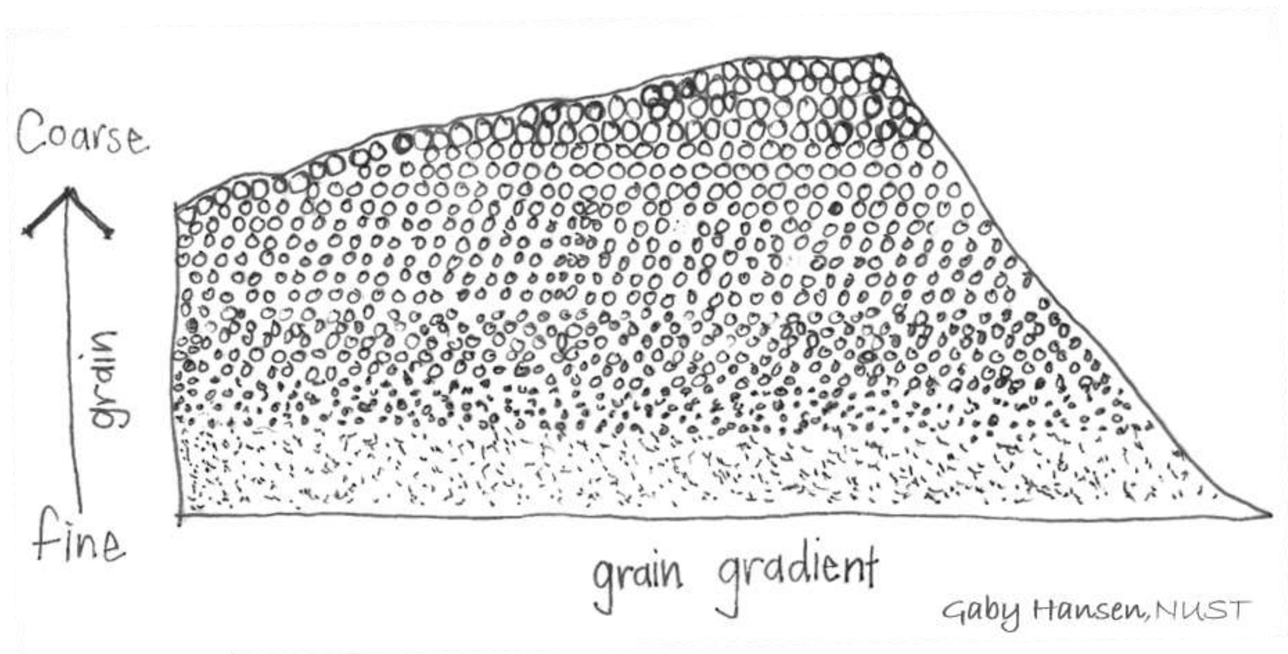

Figure 3. Grain gradient *(Gaby Hansen)*

Larger, heavier particles tend to accumulate on the windward slopes, where minerals such as magnetite, ilmenite, basalt and garnet impart a dark grey-blackish and reddish sheen to dunes.

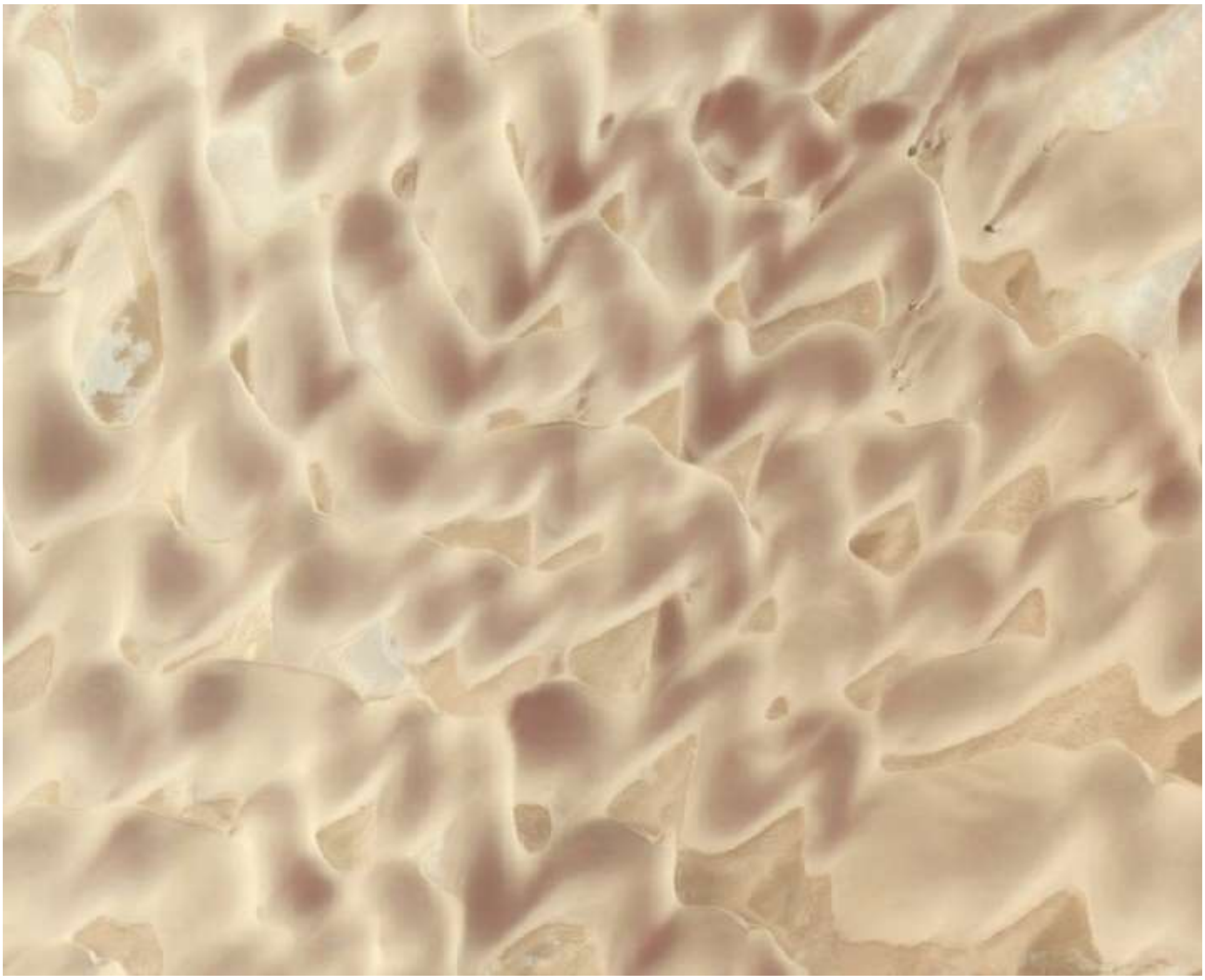

Figure 4. Dunes with garnet accumulation on the upwind side *(Bing Aerial image)*

Figure 5. Garnet grains accumulate on sand ripples *(Alex Derr)*

Figure 6. Basalt grains accumulate on sand ripples and against obstacles *(Marina Coetzee)*

SOURCES

Dansie, A.P., Thomas, D.S.G., Wiggs, G.F.S., and Munkittrick K.R. (2018). Spatial variability of ocean fertilizing nutrients in the dust-emitting ephemeral river catchments of Namibia. *Earth Surf. Process. Landforms* 43, 563–578.

Garzanti, E., Vermeesch, P., Andò, S., Lustrino, M., Padoan, M., and Vezzoli, G. (2014). Ultra-long distance littoral transport of Orange sand and provenance of the Skeleton Coast Erg (Namibia). *Marine Geology*, 357, 25-36. doi:10.1016/j.margeo.2014.07.005

Goudie, A. (2011). Parabolic Dunes: Distribution, form, morphology and change. *Annals of Arid Zone* 50(3&4): 1-7

Goudie, A.S. (2013). *Arid and semi-arid geomorphology*. New York: Cambridge University Press.

Goudie, A.S. (2007). Desert landforms in Namibia – a Landsat interpretation. In: A.S. Goudie & J. Kalvoda (eds.). *Geomorphological variations*, pp 19-36. Prague: Nakladatelstvi P3 K.

Goudie, A., and Viles, H. (2015). *Landscapes and landforms of Namibia*. World Geomorphological Landscapes. Dordrecht, Netherlands: Springer Science & Business Media.

Hartmann, K., Brunotte, E. (2008). The genesis and current reshaping of dunes at the eastern margin of the northern Namib Desert (Hartmann Valley, NW Namibia). Modelled wind-flow patterns, multitemporal aerial photograph analysis and anthropogenic morphodynamics. *Zeitschrift für Geomorphologie*, 52, 1-14.

Lancaster, N. (1982). Dunes on the Skeleton Coast, Namibia (South West Africa): geomorphology and grain size relationships. *Earth Surface Processes and Landforms*, 7, 575-587.

Lancaster, N. (2000). Eolian deposits. In: Partridge, T.C. & Maud, R.R. (eds). *The Cenozoic of Southern Africa.* Oxford University Press, Oxford, 73–87.

Lancaster, N. (2014) Dune systems of the Namib Desert – a spatial and temporal perspective. *Transactions of the Royal Society of South Africa*, 69, 133-137.

Miller, R. M. (ed.) (2008c). *The geology of Namibia. Volume 3. Upper Palaeozoic to Cenozoic.* Windhoek: Geological Survey of Namibia, Ministry of Mines and Energy.

NASA. (2015). NASA Satellite Reveals How Much Saharan Dust Feeds Amazon's Plants. Web article retrieved on 6 March 2019 from https://www.nasa.gov/content/goddard/nasa-satellite-reveals-how-much-saharan-dust-feeds-amazon-s-plants.

Thomas, D.S.G., and Goudie, A. (ed.). (2000). *The dictionary of physical geography* (3rd ed.) Oxford: Blackwell Publishers.