Linear Dunes on Earth and Mars – Comparative Research

Haim Tsoar, Department of Geography and Environmental Development, Ben Gurion University of the Negev, Beer Sheva, Israel

There is more than one sand dune type characterized by a linear or a longitudinal pattern. These linear dunes fall into two type categories, characterized by a simple, longitudinal pattern corresponding to vegetated and un-vegetated surfaces. While the former are known as vegetated linear dunes (VLDs), the latter are better named seif (sword in Arabic), because of the sharp crest. Another dune type that resembles seif dune is lee dune that has linear shape with a sharp-edged crest and is formed from sand that accumulates at the lee side of obstacles such as boulders, cliffs, shrubs or bushes. Seif dunes are known in the driest deserts, where vegetation cannot survive, such as the Namib or the Sahara. A typical characteristic of the seif dune is the sinuosity of the crest. From its primary formation, seif dune is affected by wind flows coming obliquely from both sides of its slopes, meeting the dune at an acute angle of attack and separating over the crest-line.

VLDs have a different shape with a rounded crest. They are sparsely or densely covered by vegetation. VLDs may run in parallel for scores of kilometers and are known to cover vast areas of the deserts of Australia and the Kalahari in South Africa. Vegetated linear dunes extend parallel to the dominant wind direction and can be formed in areas with unidirectional winds.

High resolution images from MGS and MRO reveal, in detail, linear dunes on Mars that were not discerned in old Viking images. Meandering seif dunes are rare on Mars. On the other hand, rectilinear dunes that have sharp crest line, similar to that of a seif, are more common on Mars. We assume that the differences in the shape of linear dunes on Earth and Mars stem from the phenomenon of induration of the dunes (crust formation) on Mars and especially in the Martian North Polar Region. Some Martian seif dunes have a different morphology, particularly as evident in the Martian North Polar Region.

Induration of the dunes, or crust formation, can explain the occurrence of these dunes of unusual morphology in the Martian North Polar Region. Crusts may form as water vapor diffuses into and out of the fine-grained materials on the planet’s surface. Salts would be
deposited as intergranular cement. Because these bedforms occur in the polar region, the cementing agent could be ice instead of salts; indeed, the dunes spend more than half each Martian year beneath a covering of seasonal frost, mostly frozen carbon dioxide. Short lee dunes that have a linear shape with a sharp-edged crest form from sand accumulation at the lee side of obstacles. Once a dune is stabilized by induration or crust, it functions as an obstacle to the wind. Linear lee dunes stabilized by ice (water or carbon dioxide) or mineral crust may elongate and form a long linear dune that aligns parallel to the wind. Melting of the ice will set up a straight linear dune, with loose sand, parallel to the dominant wind. Field observations on terrestrial deserts show that such a dune can only be formed when it is covered by vegetation. If vegetation is removed the bare linear dune disintegrates into small barchans. Simulation also shows that linear dune is unstable and deforms until it takes the shape of a string of barchans, which are the stable shape under unidirectional winds.