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SAND DUNES

Ken Tapping, 9th October, 2018

All of us, either in desert movies like David Lean's "Lawrence of Arabia", or in real life, have seen sand dunes. They look like huge waves or crescents, up to 300 m high and 200 km long. For them to form we require two ingredients: lots of dry material with loose grains more or less the same size, and a steady, dry wind. Heat is useful because it ensures the ingredients are dry, but it is not essential. For example, there are dune fields in Canada, in Saskatchewan and British Columbia.

An absolutely steady wind blowing close to or in contact with the Earth's surface will be unstable, breaking into waves. Sand starts to accumulate under the peak of a wave. This makes the wave bigger. The wind or current blows material up the longer, upwind side of the accumulation. Eventually the ridge of sand is high enough for the flow to detach, and an eddy forms on the downstream side, which is much steeper than the upstream side. What we see is sand climbing the upstream slope and tumbling down the steep downstream side. A bit further downstream, the wind reconnects with the ground and the process starts over. The result can be wave after wave of sand, forming dune fields over thousands of kilometres. Since we know the recipe for making dunes, and the circumstances under which they form, their presence tells us a lot. This is especially useful when we see them on other worlds.

So far, we have discovered dune fields not only on Earth, but also on Mars, Titan and Pluto. Since Mars is so similar to Earth, their presence is not really surprising. Mars is mostly a cold desert. The atmosphere is very thin. At the surface, the air pressure is around 0.4 kilopascals, compared with the Earth's surface pressure of about 100 kilopascals. However the winds are strong enough to blow sand around, forming dune fields and even dust devils – mini-tornadoes of dust and sand.

The presence of dune fields on Titan, the largest moon of Saturn, the sixth planet out from the Sun – we live on the third – is more intriguing. However, in some ways it resembles the Earth more than Mars does. It has rivers, lakes and a thick atmosphere. The pressure at ground level is around 148 kilopascals, about one and a half times that here on Earth. However, the average temperature on Titan is about minus 180 degrees Celsius. On that world, water is a permanently frozen rock mineral, and those lakes and rivers are liquid hydrocarbons such as methane, and the atmosphere is mostly nitrogen gas. The particles making up the dunes could be ice or frozen hydrocarbons, and rock dust. The main requirement is that they are all sufficiently deeply frozen so as not to stick together. We know that Titan has weather as we would understand it, clouds, dust storms in the dry places, and hydrocarbon rain. The dune fields show us dry areas with steady winds, which tell us a lot about how the weather works on that cold world.

Pluto is a stranger issue. It is so cold that nitrogen, methane and the other gases driving Titan's weather are all frozen solid. The planet's surface is mostly frozen nitrogen, carbon monoxide and methane. In the Sun's heat, a tiny bit evaporates, making a very thin atmosphere of nitrogen and carbon monoxide. Particles of frozen nitrogen and methane would be good raw materials for dunes. However, there are two big questions: firstly, how did the frozen material get divided into lots of loose particles and secondly, what is blowing them around. Pluto's atmosphere is around a million times thinner than Earth's. However, it appears that if the particles are small enough, on a world with weaker gravity than Earth, even with a very thin atmosphere the wind could be strong enough.

Jupiter is vanishing in the sunset glow. Saturn lies low in the south–southwest after dark and Mars is still conspicuous in the south-southeast. The Moon will reach First Quarter on the 16th.

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