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When do pyroclastic particles move? Wind tunnel experiments on saltation threshold and surface roughness.

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Our understanding of the dynamics of pyroclastic density currents (PDCs) is largely based on the study of their deposits. Pyroclasts have strongly deviating properties in density and angularity compared to the wind blown and fluvial sand usually studied in clastic sedimentology. In order to test whether these specificities have an impact on the sedimentation processes and dynamic behavior of dilute PDCs, wind tunnel experiments were carried out in order to characterize the onset of saltation and surface roughness induced by pyroclastic material.
Saltation is the major transport process occurring at the boundary between a flow and the sediment, and corresponds to alternate, sub-planar jumps and landing of particles on the ground. The surface roughness is a measure of how rough a bed is seen by a wind, and is a property of the bed depending on grains' size and shape. The static saltation threshold corresponds to the minimum shearing necessary for particles to be lifted off the ground and begin to bounce. The dynamic saltation threshold corresponds to the minimum shearing necessary to maintain an already saltating bed in that state.

Experiments were done in a 6 m long, inclinable, wind tunnel in Aarhus (Denmark). Two sample types (pumices and scoriaceous particles) were investigated individually at 1 Phi grain-size intervals between 0.125 and 16 mm. The surface roughness was measured over a quiescent bed of particles. The static saltation threshold was derived from wind profiles reaching the onset of particle transport and was measured for bed slopes between -20º and 25º (every 5º).

The surface roughness measured are of the order expected for rounded particles of similar grain sizes (c.a. 1/30th of the grain diameter). However, a slight deviation to smaller surface roughness is observed for particles < 1 mm, possibly due to the occurrence of a laminar sub-layer near the bed, and a deviation to higher surface roughness values for particles > 1 mm, possibly showing the increasing influence of shape for larger grains.
The static saltation thresholds (given as a shear velocity value) for horizontal surfaces show that the shearing necessary to initiate transport is smaller for fines than for coarse grains, thus only macro-scale forces are acting over the whole range of grain sizes. The shear velocity necessary to erode scoria is 2 to 3 times higher than for low-density pumices. The results agree remarkably well with standard curves for rounded particles of similar densities for both pumice and scoria, suggesting that shape is not a relevant factor in these experiments. Additionally, a downslope wind lowers the threshold shear velocity by a factor 0.6 to 0.9, whereas it increases the value when blowing upslope by a factor up to 1.2. Dynamic saltation threshold is predicted (15-20% lower than static) derived from the static saltation threshold and the ratio of dynamic over static repose angles for grain piles.

Our experimental results contribute to a better understanding of the genesis of dune bedforms produced by dilute pyroclastic density currents, provide inputs for models, and serve as analogue for other sedimentary environments (other planets, nuclear base surges). They also permit to give a lower estimate of near bed velocities for field-observed erosion-planes truncating stratification.