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Ground penetrating radar and terrestrial laser scanner surveys on deposits of dilute pyroclastic density current deposits: insights for dune bedform genesis

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Dune bedforms formed by dilute pyroclastic density currents (PDC) are often described or interpreted as antidunes and chute and pools. However, the interpretation remains essentially speculative and is not well understood. This is largely due to the seeming impossibility of in-situ measurements and experimental scaling, as well as the lack of recent, 3D exposures. Indeed, most dune bedform cross-stratifications from the dilute PDC record outcrop in 2D sections. The 2006 eruption of Tungurahua has produced well-developed bedforms that are well-exposed on the surface of the deposits with easy access.

We performed a survey of these deposits combining ground penetrating radar (GPR) profiling with terrestrial laser scanning of the surface. The GPR survey was carried in dense arrays (from 10 to 25 cm spacing between profiles) over ca. 10 m long bedforms. GPR profiles were corrected for topography from photogrammetry data. An in-house software, RadLab (written in matlab), was used for common processing of individual profiles and 2D & 3D topographic migration. Each topography-corrected profile was then loaded into a seismic interpretation software, OpenDtect, for 3D visualization and interpretation.

Most bedforms show high lateral stability that is independent of the cross-stratification pattern (that varies between stoss-aggrading bedsets, stoss-erosive bedsets and stoss-depositional lensoidal layers).

Anecdotic bedforms have their profiles that evolve laterally (i.e. in a direction perpendicular to the flow direction). Cannibalization of two dune bedforms into a single one on one end of the profile can evolve into growth of a single bedform at the other lateral end. Also, lateral variation in the migration direction occurs, i.e. a single bedform can show upstream aggradation at one lateral end of the bedform, but show downstream migration at the other end.

Some bedforms have great variations in their internal structure. Several episodes of growth and erosion can be identified and reflect the dual control of the basal boundary for the location of a bedform, but the fluids dynamics control on the sedimentation pattern.

The TLS data could not be geo-referenced and different clouds could not be combined. However, individual clouds or group of clouds permit a numerical analysis of the bedforms. Local average-extrema point the location of crests and troughs. The curvature of the surface elevation (eigenvalue of the curvature matrix) emphasizes the organization of the bedforms. Though noisy, the 2D Fourier transform permit to see a slight trend in the spectrum of a field of bedforms.

As a whole, the dataset from the Tungurahua eruption allows us to rule out the interpretation as antidune that has been made for similar deposits. The outer shape of the bedforms and their internal structures are, in particular, not coherent with antidunes, and the downstream-size evolution as well as the outer shapes are not in agreement with interpretation of flow reversal for the formation of stoss-aggrading dune bedforms.