Ground Penetrating Radar and Terrestrial Laser Scanner survey on cross-stratified overbank deposits from the 2006 eruption of Tungurahua volcano, Ecuador.

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The deposits of the August 2006 pyroclastic density currents (PDCs) at Tungurahua, Ecuador exhibit two main depositional characteristics. Topography confined deposits show coarse, unsorted, massive, meter thick layers. Ash dominated, cross stratified deposits outcrop on the overbanks of valleys, organized as spatially isolated and limited bodies. Dune bedforms shape the surface of these deposits. We combined a terrestrial laser scanner (TLS) and a ground penetrating radar (GPR) survey on the overbank deposits.

TLS provides a dense data cloud (measurements at ca. 5cm steps) with cm precision. The GPR survey permits to look at the internal cross stratification patterns in a non destructive way. Three antennae with frequencies of 250, 500 and 800MHz, permitted to image the deposits down to 10, 7 and 3m depth, resp. The GPR data profits from the TLS results, which are integrated in the processing.

The TLS results permitted to compare previous eyewitness measurements with quantitative parameters derived from the numerical data. We picked the crests of the dune bedforms by defining them as local maxima. Their orientations, average slope angles, length and thickness are defined from two successive local extrema. We applied a Fourier and wavelet analysis in all directions to characterize wavelengths and pseudo amplitudes.

A large gridding with the 250MHz antenna permitted to recognize and follow the major flow units and the pre eruptive surface. Up to 6 units are recognized, the 3 basal ones interpreted as dense pyroclastic flows deposits and the top ones as dilute PDCs deposits, based on the GPR signal. This may indicate that the valleys were filled by the time of deposition of the dune bedforms, a result not inferred in previous studies. The deposited volume can also be derived.

From a dense array (profiles at 10cm spacing) over dune bedforms with the 800 and 500MHz antennae, we imaged the 3D internal patterns. This confirmed previous 2D, outcrop based observations and constrained the lateral evolution of stratigraphic features. Monotone lateral profiles rule out genesis from currents with different orientations. However, a single dune bedform can show both downstream and upstream migrating crests during the same stage of the flow. The root of the structures is located much deeper than previously expected and record the initial conditions for initiation of a bedform. The striking spatial stability during the whole deposition stage indicates that these bedforms are triggered by basal topographic disturbances. Several structures cannibalized by larger ones proof that the bed rapidly accommodates temporal changes in the dynamics of the currents.

This innovative combination of field methods brought unexpectedly good results. In particular, they permitted to image individual flow events and how deposits from successive pulses interacted with each other.