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Advances in field work approach on volcanic debris avalanche deposits: understanding their context and explaining processes using facies analysis

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Volcanic debris avalanche deposits (VDADs) have the particularity to present a greater diversity of facies than any other volcanic deposit. Their description is fundamental to decipher the complexity of rockslide-debris avalanches. The variety of rock types, structures and textures is responsible for the multiplication of facies terms in literature. Despite several attempts to build coherent terminologies we must face the fact that it is almost impossible to compare the facies observations made on different VDADs. The terms "block facies" and "mixed facies" are widely used but they provide little information on the phenomenon. Facies must be defined in order to get meaningful information on the sector collapse origin and the flow mechanisms. We propose a descriptive strategy and its associated terminology based on literature and personal experience to improve facies analysis. We illustrate this approach with observations made on Chimborazo DAD in Ecuador.

A facies is generally defined by a unique character that distinguishes one formation from another. In the particular case of VDADs, we want to use facies description to answer questions about either the event context or the collapse and emplacement mechanisms. Context questions are for example: which part of the volcano collapsed? Why did it collapse? What was the topography and nature of the emplacement setting before the rockslide-debris avalanche? Process questions are for example: What parameters influence the collapse of a volcano? How the topography and nature of the emplacement setting influence the flow? What flow mechanisms explain the presence of typical DAD features such as jigsaw cracks, hummocks, injections, and block deformation? Our strategy is to segment the facies description in two stages. The first stage contains only three well defined terms and makes easier the comparison between different deposits: edifice-derived, substratum-derived and mixed facies. The quantification of each facies helps to calculate the sector collapse volume and the amount of erosion and expansion during transport. The second stage is based on the lithology and contains an undefined number of more descriptive facies terms. The lithology description includes the physical constituents (lava, pyroclastic, autoclastic, epiclastic, non-volcanic), composition (geochemical, mineralogical and petrological character) and texture (grain size, rounding, sorting, shape and fabric). Such description gives information on the volcano history, the pre-collapse state, the collapse triggering mechanism, and the transport path nature.

Chimborazo DAD is a large (∼280 km2 and >11 km3), well exposed, Late Pleistocene deposit with a preserved hummocky topography and few erosion/cover. The collapse volume is estimated at 8 km3. We mapped the main local facies throughout the Riobamba Basin and calculated that the edifice-derived facies and the mixed facies correspond to respectively 80-85 vol.% and 15-20 vol.% of the deposit. The lithological analysis allows us to estimate that 50-70 vol.% of the mixed facies comes from erosion of the transport path. Consequently we assess that the rockslide-debris avalanche suffered an expansion of 15-25 vol.% and incorporated about 1.5 km3 of material during emplacement. From to the lithological analysis we were also able to determine the pre-collapse state and history of Chimborazo volcano. The presence of dacitic pyroclastic facies in the deposit informs us that the pre-collapse edifice was not only a andesitic lavic edifice. The lack of hydrothermally altered material in the deposit discards alteration as a weakening mechanism for Chimborazo collapse.

In conclusion we show that any study on sector collapse and debris avalanche emplacement mechanisms require a rigorous facies analysis in order to separate context information from process evidence during field work.