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High Andean Soil Landscapes Shaped by Interactions between Geomorphology, Vegetation, and Hydrology

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Physical and chemical weathering processes fulfil a crucial function in the biogeochemistry of terrestrial ecosystems. Rock□derived weathering products provide essential plant nutrients, and regulate the chemical composition of soil, surface, and groundwater. The rate and extent of chemical weathering are influenced by the combined effects of climate, parent material, topography, and vegetation, and ultimately determine the mineral composition and element ratios of soil material. Understanding the spatial variation of rock□derived weathering products across heterogeneous landscapes not only relies on knowledge of the environmental controls but also of their interactions.

High Andean tropical ecosystems provide a good opportunity to study the association between chemical weathering, local topography and vegetation patterns: the climate, parent material and soil age can be held constant at the landscape scale, while the vegetation and slope morphology can vary greatly from the hilltops to the valley bottoms. In this study, we selected 10 soil toposequences on andesitic flows: 5 under tussock grasses, 3 under cushion forming plants and 2 under native forest. A marginally significant increase in base cation depletion is observed along topographic gradients that can be associated with physical transport of weathered soil particles downslope or subsurface water fluxes. Beyond the hillslope-scale topographic control on chemical weathering extent, we observed highly significant differences in chemical weathering extent between vegetation communities with total mass losses in forest soils being respectively 19% and 22% higher than in grasslands and cushion forming plants. Although biotic factors can play a role in creating the observed patterns in soil development, the vegetation communities can also hint to the existence of hillslope micro-topography and subsurface hydrological patterns that are challenging to map in the field.