Delimiting the soil/saprolite transition using a multi-tracer approach

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Processes occuring throughout regoliths contribute to critical zone functions, but certain regions within them have proportionally larger roles. One of these 'hotspots' is the saprolite-soil transition. In this work we studied a highly leached, 9.7 m deep regolith developed on a ridgetop in the Luquillo Critical Zone Observatory, a wet-tropical montane forest in Puerto Rico. We analyzed its variations with depth, starting with basic physical, mineralogical and geochemical data, followed by REEs and Mg isotope ratios to better understand nutrient cycles and to constrain controls on the location of this crucial interface.

The pH, bulk density, water content, mineralogy and major element chemistry indicates an anomalous zone from 0.91 m to 1.52 m depth. This zone has redoximorphic features that evidence contrasting redox conditions: mottling at the top, indicative of alternating redox status, followed by a red horizon and a pale coloured layer suggestive of more permanent oxidizing and reducing conditions, respectively. We hypothesize that this could constitute a threshold for the biogoechemical cycling of elements, where surface and deep cycles become decoupled, as is commonly seen in deep tropical regolith.

LREE/HREE differentiated behaviour and an alternating positive-negative Ce anomaly further indicate that this 60 cm zone is a redox hotspot, where redox conditions fluctuate, controlling the precipitation and sorption of redox sensitive species such as Fe-Mn-oxides and REE+Y. Mg isotope ratios in pore water show a 25% shift towards heavier values at the hotspot, relative to the overall depth trend, indicating that the divergence in the Mg-cycle occurs on the short time scale represented by the water residence time (1-2 y).

We conclude that the redox fluctuations induce a fundamental change in the mineralogy of the regolith at the hotspot, impacting weathering fluxes and nutrient transport both above and below it.