U-series disequilibrium investigation of a weathering profile in a tropical granitoid watershed, Luquillo, Puerto Rico

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Understanding how weathering profiles develop over time is a key to understanding biogeochemical cycling and the controls on chemical fluxes from land to the oceans. Isotopic tracers that identify and date chemical transformations in those profiles can provide essential knowledge for understanding profile development and calculating watershed scale weathering rates.

We have investifated the use of U-series disequilibrium to examine weathering profile development in the Rio Icacos watershed in the Luquillo Mountains of Puerto Rico. In order to further constrain interpretations based on U-series data, we have coupled the U-series analyses with analyses of trace element concentrations and Ge/Si and $^{87}Sr/^{86}Sr$ ratios. Used together, these geochemical tracers provide a powerful tool for understanding weathering reactions, chemical transfers within and out of the profile, and the timing of those chemical transfers.

$^{234}U/^{238}U$ activity ratios in soil, saprolite and pore water samples reveal a complex history of U transformations dominated by two distinct weathering fronts in the Rio Icacos profile. Significant disequilibria exists between deep saprolite samples (8 m) and pore waters from the same depth, with higher $^{234}U/^{238}U$ in pore waters reflecting α-recoil emplacement of ^{234}U during weathering. $^{234}U/^{238}U$ activity ratios in both saprolite samples and pore waters decrease towards the surface of the profile. $^{234}U/^{238}U$ activity ratios in the soil (top 50 cm) are distinct in that the pore waters and soil samples have very similar $^{234}U/^{238}U$ activity ratios, a lack of fractionation reflecting more intense weathering conditions in this zone. Trace element and REE abundance patterns throughout the profile illustrate redistribution of elements from shallower saprolite to a zone of accumulation between 4 and 7 m depth. These patterns also reveal a distinct enrichment in the top 30 cm of the profile indicating a significant atmospheric contribution that must be taken into account. Finally, simple modeling exercises are undertaken to examine possible scenarios for the observed patterns in U/Th and $^{234}U/^{238}U$ and $^{230}Th/^{238}U$ activity ratios.