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Constraining mechanisms involved in the long-term laterite formation using a multi-isotopic approach (Cr, Fe, Li)

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Lateritic covers are deep weathering profiles developed in tectonically quiescent areas under tropical conditions for millions of years. Their formation which depend on a complex interplay between climatic, environmental, and hydrological drivers, results from long-term chemical weathering involving variation of redox conditions. This study illustrates the insight offered by stable isotope geochemistry on a 15-m-long Amazonian lateritic profile developed on sedimentary bedrock. Chromium (Cr) and iron (Fe) isotopes are sensitive to redox fluctuations and have been used to illuminate the processes of iron duricrust formation, while lithium (Li) isotopes have been used to highlight weathering profile formation by comparing their record with silicon (Si) isotopes.

Chromium and Fe isotopes present limited variations throughout the weathering profile, except in the duricrust level, where both systems fractionate to heavy signatures and Fe, Cr and other redox reactive species (e.g., As or V) are enriched. Fe-lateritic duricrust formation is controlled by hydrology, which is based on lateral advection of Fe(II)-rich groundwater and local precipitation of Fe(III) oxide at the oxic-anoxic fluctuation level. The elevated δ^{53}Cr in duricrust shows that Cr(VI) was released in solution through Cr oxidation, co-transported laterally with Fe, and quantitively co-precipitated within iron oxides.

The studied profile was also interpreted based on Si isotope depletion atop the profile as the result of a weathering phase having caused the replacement of a first kaolinite generation by a new population through dissolution-precipitation [1]. The Li concentration pattern is similar to that of Si, with an almost total depletion and a rather invariant δ^7Li in the <2 µm clay fraction across the whole profile. While light Li isotope enrichment (-10±5 ‰) is consistent with kaolinite formation, its stability through the profile suggests that, unlike Si, Li is not impacted by kinetic isotope fractionation during clay formation. Interestingly, the bulk soil fraction is recording one of the most positive δ^7Li ever observed (up to 28 ‰). Together with Si-rich horizons and the occurrence of La-Pb-rich phosphate, this observation questions the role of atmospheric inputs or enhanced water-rock interactions on late mineral reprecipitation.

[1] Ansart et al. (2025),Pal3, 662, 112674.