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Formation and Evolution of Weathering Profiles: Combined Study of Trace Elements, Sr Isotopes and U-Th Disequilibria

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Isotopic dating of weathering profiles is important for understanding mass transfer related to rock weathering. Often contradictory dates result from uses of different chronometers on the studied profiles. A geochemical approach to the solution of the problem is proposed, combining studies of trace elements concentrations, Sr isotopes and U-Th disequilibria on a lateritic profile from Burkina Faso (Kaya 5). This profile is 15 meters deep, developed on a granodioritic basement and is composed of a pistachio clay level at the base, a pink clay level in the middle part and an iron crust at the top. It is marked by a progressive disappearance of the primary minerals (amphibole, micas, plagioclase and finally K-felspar) and an evolution of secondary phase associations that include kaolinite - illite-smectite at the base, kaolinite - goethite in the middle part, and kaolinite - goethite - hematite at the top.

The chemical composition of the fifteen samples compared to the bedrock shows the rapid exportation of such soluble elements as Na, K, Ca, Sr and Rb out of the profile. The evolution of the Sr isotopes ratio is associated with the progressive weathering of the different primary minerals with possible external input at the top of the ferruginous hardcap. Other less mobile elements show wide concentration variations. Thorium is taken to be one of the less mobile elements and is used as a reference for assessing relative mobilities of other elements. Rare earth elements are depleted relative to Th in the upper part of the profile, accumulated in the middle and lower part, and immobile at the base. No significant input or output of lanthanides is detected when calculating a mass balance along the profile. Thus, the observed variations indicate a vertical redistribution of the rare earth elements into the studied lateritic profile, which can be linked to the disaggregation of the ferruginous crust.

Uranium is also immobile relative to thorium at the scale of the profile but shows a complex behaviour relative to Th. The $^{234}U/^{238}U$ activity ratios show, as for lanthanides, a depletion of ^{234}U in the upper part ($^{234}U/^{238}U < 1$) and an accumulation in the lower part ($^{234}U/^{238}U > 1$). In contrast, U/Th concentration ratios and $^{230}Th/^{234}U$ activity ratios point to an accumulation of uranium at the top and a depletion below. The contradictory interpretations obtained using the U-Th disequilibria imply the coexistence of two concomitant processes of depletion and accumulation of uranium in each level of the profile. The uranium leaching and accumulation phenomena can be linked respectively to the processes of Sr isotope variations and lanthanides redistributions. Thus, the alteration of the primary minerals and the remobilization of some elements are both currently active (less than 1Ma) in the Kaya profile.

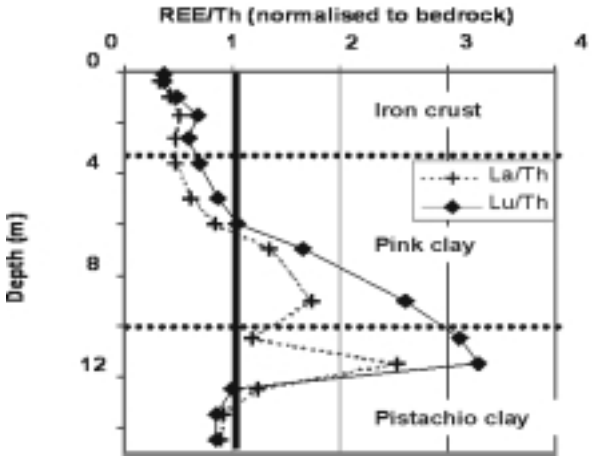

Figure 1: REE/Th (normalised to bedrock)

Relative mobility of lanthanides relative to Th showing a vertical redistribution of elements