Are shallowest soil horizons suitable for U-series soil-production rates determination?

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Over the last decades, the U- and Th-series isotopes were successfully used to determine weathering rates in various environments. The objective of this study was to work out the origin of the complex trend often observed in the shallowest soil horizons, including the potential role of the vegetation. This study was carried out from the experimental forest site of Breuil (Morvan, France) developed by INRA-BEF, in which the native forest was partially clear-felled 37 years ago and replaced by monospecific plantations (Oak, Douglas, etc…). U-series disequilibrium were measured in four soil profiles developed on granite under the native forest, and replanted stands. Selective extractions of the Fe and Al amorphous and well crystallized oxides were performed in order to investigate the distribution of U and Th among these soil phases. A careful investigation of the lack of fractionation between U and Th isotopes during such extractions was performed, using U- and Th-dopped synthetical oxides. The ($^{234}U/^{238}U$) and ($^{230}Th/^{234}U$) activity ratios were measured in the amorphous oxides fraction extracted from several soil layers through one profile.

Our results demonstrate that some podzolic pedogenic processes significantly impact the shallowest soil layers (0-40cm) of this site. A significant part of U and Th is primary hold by Fe-bearing silicates, and land cover change can produce a large dissolution of these minerals, resulting in a important release of U and Th. Further pedogenic redistribution of these isotopes occurs in all the profiles, yielding for instance to an enhance mobilization of ^{230}Th relative to all the other nuclides (including ^{232}Th). The clear correlation between the ($^{230}Th/^{234}U$) ratios and the proportions of amorphous and interlayer Al hydroxides suggests that in these soils the mobility of U and Th isotopes is strongly associated to Al dynamic, rather than Fe, despite the overwhelming reported control of U by Fe-oxides in oxidized environments. These pedogenic processes make the shallowest horizons of podzolic soils unsuitable for U-series dating. In contrast, a soil production rate can be deduced from the deepest soil layers which do not show such effects on the U-series nuclides.