Short-lived nuclides of the U and Th-series probing recent pedogenic processes in soils

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The recent chemical dynamic occurring in a podzolic forest soil section (from the Strengbach watershed, France) was investigated using U and Th-series nuclides, including short-lived nuclides. Analyses of (^{230}Th), (^{226}Ra), (^{232}Th), (^{228}Ra) and (^{228}Th) activities in the soil particles, the seepage waters, the roots and the mature leaves of the beeches growing on this soil were performed by mass spectrometry (TIMS) or gamma spectrometry. Moreover, the exchangeable fraction was extracted from the soil particle and analysed. The simultaneous analysis of the different soil (*sl*) compartments allows to demonstrate that the overall Ra and Th transfer scheme is fully consistent with the acido-complexolysis weathering mechanism prevailing in podzols. Using a continuous open-system leaching model, the coupled (^{226}Ra/^{230}Th) and (^{228}Ra/^{232}Th) disequilibria measured in the different soil layers permit to date the contemporary processes such as recent (< 18 years) change in organic-colloids migration occurring in the shallow soil horizons. The Monte Carlo simulation approach used to resolve this system shows that a semi-infinite range of Th-isotopes leaching rates can explain the observed data, but minimum values can be inferred, leading to an upper limit age for the beginning of the perturbation. The model predicts distinct leaching rates of Th isotopes, in excellent agreement with the apparent preferential ^{230}Th over ^{232}Th leaching recorded in seepage water. The lower soil horizons are also affected by such Th mobilization, though lasting over several centuries at least, with a much smaller leaching rate.

Ra and Th isotopic ratios also appear to be valuable tracers of some mineral-water-plant interactions occurring in a soil. The (^{228}Ra/^{226}Ra) ratio discriminate the Ra flux originating from leaves degradation and from mineral weathering in the shallow -10cm seepage soil waters. This ratio, combined to the ^{232}Th-^{228}Ra-^{228}Th radioactive disequilibria measured in the different soil compartments allows to constaint the shallow bio-geochemical cycle of Ra, including residence time in vegetation cycling and scavenging in the soil exchangeable fraction.

Intrabasaltic paleosols from the North Atlantic Igneous Province record late Paleocene global climate trends and hyperthermals

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Weathering of basaltic tephra and lava produces clays preserved in intrabasaltic paleosols. We propose that hydrogen isotopes of smectite clays formed by weathering of intraflow tephras (redbeds) of the North Atlantic Igneous Province preserve isotopic records of past global climate. In support we present smectite δD compositions of 70 tephras from West (~61.5-60.0 Ma) and East (~56.5-55.0 Ma) Greenland (64-66°N paleolatitude) for comparative analysis with global paleoclimate trends and aberrations recorded in higher-resolution marine records.

The observed smectite δD compositions range from -145 to -104 ‰. In the East Greenland section smectite δD varies around -130 to -120 ‰ at ~56 Ma prior to an abrupt increase to a maximum of -104 ‰ before returning gradually to -117 ‰ at ~55 Ma. This trend corresponds inversely to the δ^{18}O deep-sea foraminifera record depicting a warming trend from mid-Paleocene (~59 Ma) towards the Early Eocene Climatic Optimum (~52 Ma) superimposed with the Paleocene-Eocene Thermal Maximum (~55.5 Ma). The ~5 m. y. older West Greenland tephras display an initial abrupt increase in smectite δD from around -135 to -130 ‰ up to ~-120 ‰, followed by a more gradual decrease to ~-140 ‰. The more depleted δD compositions reported from West Greenland relative to East Greenland are in agreement with the cooler global conditions that prevailed in the earliest Paleocene (65-58 Ma). While the general decrease to ~-140 ‰ correlates with global cooling towards 59 Ma, we suggest that the initial increase in smectite δD from West Greenland could be recording a similar, but weaker, hyperthermal as the PETM.

We speculate that both the East and West Greenland continental flood basalt volcanism had an indirect short-lived warming effect through release of methane from organic-rich sediments by contact metamorphism from overflowing lavas and sill intrusions, as well as a direct longer-lasting cooling effect through degassing of SO_2.