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Si isotopes record cyclical dissolution and re-precipitation of pedogenic clay minerals in a podzolic soil chronosequence

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Soils are a major resource on the planet, acting as a key component for ecosystem function. The secondary minerals in the clay fraction are important players in soil biogeochemical processes as they provide a large reactive surface area. However, the origin and evolution of secondary minerals in soils are not yet fully understood.

We determined the Si isotope compositions in the clay fraction of a podzolic soil chronosequence and document light ^{28}Si enrichment during pedogenesis that increases with soil age. Relative to the original "unweathered" clay-size minerals in deepsoil (δ^{30}Si = -0.52$\pm$0.16 permil), the clay fraction of the topsoil eluvial horizon show less negative δ^{30}Si values (δ^{30}Sifrom -0.33 to -0.10 permil), while the clay fraction of the subsoil illuvial horizons is isotopically lighter (δ^{30}Si from -0.60 to -0.84 permil). Geochemical and X-ray diffraction analyses show that the on-going enrichment in light ^{28}Si in pedogenic minerals of illuvial subsoil horizons can only be related to the dissolution in the topsoil horizon of clay minerals previously enriched in ^{28}Si. The ^{28}Si enrichment in the clay fraction with pedogenesis and soil age provides consistent evidence for the cyclical dissolution and re-precipitation of pedogenic minerals. Our study shows that the successive generations of clay minerals occur over very short time scales (ca. 300 years). This is instrumental in the evolution of the clay mineral genesis in soils.

This soil-forming process has implications for the modeling of soil evolution. Given the importance of clay minerals in the chemical cycles of elements, deciphering the origin of pedogenic Si in clay mineral genesis is central to a better understanding of soil development and associated terrestrial biogeochemical processes.