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Silicon isotope signatures in soils determined by UV femtosecond laser ablation

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The formation of soils represents an important part of the global biogeochemical Si cycle, because silicate weathering consumes atmospheric CO_2 and drives the flux of continental Si to the ocean. The release or precipitation of Si during abiotic or biotic processes in soils is associated with significant stable Si isotope fractionation. Here, we present the first Si isotope data of the principle Si pools in soils determined by a UV femtoseond laser ablation system coupled to a multicollector inductively coupled plasma mass spectrometer (MC-ICP-MS). This approach provides the opportunity to obtain precise and accurate data on bulk sample materials and at high spatial resolution, on the mineral scale. Bulk soils, separated clay fractions and biogenic opal, i. e. phytolith were either analysed as pressed powder pellets or as glass beads fused by an iridium strip-heater. To investigate the Si source to soils, we analysed all major silicate minerals on thin sections from bedrock samples.

We investigated rock standards and two immature Cambisols developed on sandstone and paragneiss in the Black Forest, Germany, respectively, to verify our approach. Bulk soils show a largely homogeneous Si isotope signature for different horizons and locations, which is close to those of bulk bedrocks with δ^{30} Si value around -0.3 ‰. Soil clay formation is associated with limited Si mobility, which preserves initial Si isotope signatures of parental minerals. An exception is the top soil layer in the paragneiss catchment where the organic-rich environment promotes high Si mobility, which leads to a significant depletion of heavy Si isotopes in this horizon. Biogenic mineral, i.e. phytoliths, exhibit negative Si isotope signature of about -0.4 ‰. These results demonstrate that UV femtosecond laser ablation ICP-MS provides a tool to characterize the Si isotope signature of the principle Si pools to explain weathering and Si transport processes in residual solids. These findings can then be used to identify the source of dissolved Si in soil solution and rivers, which shows commonly positive Si isotope signatures.