Impact of the soil weathering degree on the fate of soil organic carbon, Fe and Si: insights from Si and Fe isotopes in Icelandic soils

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The soil weathering degree changes the mineralogy of secondary phases which, in turn, not only affects the soil organic carbon (SOC) dynamics but also controls the fate of Fe and Si and dissolved Fe and Si fluxes exported from soils to the hydrosphere. Constraining the relationship between weathering in soils and the fate of SOC, Fe and Si is central to understanding the link between the C cyle and the global biogeochemical cycles of Fe and Si, two key oceanic nutrients.

Icelandic soils provide an ideal natural laboratory to study these processes, and we have focused on five soil profiles developed on the same parent basalt and exhibiting contrasted weathering degree. Secondary phases are dominated by short-range ordered minerals such as allophane and ferrihydrite. In more weathered soils, free Fe-oxides are more abundant and proportionally more cristalline. We have quantified the SOC pools by horizons, determined organic carbon (OC) mineralisation rates under controlled conditions, and carried out Fe and Si isotope determinations of bulk soils, secondary phases and soil solutions.

The results indicate a relatively higher OC mineralisation in less weathered soils, and suggest that the mean residence time of OC in soils increases with the amount of free Fe-oxides. The Fe and Si isotope compositions of solid and dissolved phases indicate that dissolved Fe and Si in soil solutions originate from the dissolution of Fe-oxides and the release of Si adsorbed onto Fe-oxides. This is enhanced in more weathered soils relative to less weathered, which have lower content of Fe-oxides.

This study suggests that the fate of SOC, Fe and Si in Icelandic soils is strongly related to the formation of Fe-oxides with increasing weathering.