



Multidecadal persistence of organic matter in soils: insights from spatially resolved investigations at the submicrometer scale

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Better understanding the mechanisms responsible for the pluri-decadal persistence of carbon in soils requires well constraining the dynamics, the distribution and the chemical nature of both the soil organic carbon (SOC) and the associated mineral phases. The question we address in this work is whether different mineral species lead to different organo-mineral interactions and stabilize different quantities of SOM and different types of SOC.

Here, benefiting from the unique opportunity offered by an INRA long term bare fallow (LTBF) experiment having started in 1928 in Versailles (France), we report the in-situ characterization of SOC dynamics in four clay fractions of this silty loam soil (total clays [TC, $<2\mu\text{m}$], coarse clays [CC, $0.2\text{-}2\mu\text{m}$], intermediate clays [IC, $0.05\text{-}0.2\mu\text{m}$] and fine clays [FC, $0\text{-}0.05\mu\text{m}$]). The IC and FC fractions only contain smectite and illite/smectite mixed-layered clay minerals while the CC fraction also contains illite and kaolinite. In the absence of any carbon input, the plant-free LTBF clay fractions from Versailles progressively lost SOC during the first 50 years of the experiment, until they reached a seemingly stable concentration. Of note, the investigated clay fractions did not lose the same amount of SOC and do not exhibit the same final carbon concentrations. The decrease of the organic C:N ratios with LTBF duration corresponds to a progressive enrichment in N-rich SOC for all fractions which can be attributed to microbial material. Even though the speciation of SOC appears to only slightly evolve with LTBF duration, an enrichment in carboxyl and carbonyl groups is revealed by bulk-scale C-NEXAFS data for SOC from all clay fractions. In addition, STXM-based NEXAFS investigations at the submicrometer scale reveal three types of SOC-clay assemblages in addition to clay-free SOC and organic-free clays. While SOC appears mostly adsorbed onto clay surfaces within the IC and FC fractions, other protection mechanisms occur within the CC fraction. Altogether, the present study suggests that smectite have more efficient protection capabilities than those of illite and kaolinite.