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Mineralogical control of soil organic carbon persistence at the multidecadal time scale

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One of the current challenges in understanding the long term persistence of organic carbon in soils is to assess how mineral surfaces, especially at small scale, can stabilize soil organic carbon (SOC). The question we address in this work is whether different mineral species stabilize different types of SOC.
Here we used the unique opportunity offered by long term bare fallows to study in situ C dynamics in several fine fractions of a silty loam soil. Indeed, with no vegetation i.e. no external input of fresh C, the plant-free soil of the Versailles 42 Plots (INRA, France) has been progressively enriched in persistent SOC during the 80 years of bare fallow.

To separate mineral phases of the clay size fraction we performed a size fractionation on samples taken from 4 different plots at 5 different dates (0, 10, 22, 52, and 79 years after the beginning of the BF) and analyzed the SOC in the different fractions thus obtained.
First, the clay fraction (< 2 μm) was isolated by wet sieving and centrifugation in water. Then, the clay fraction was further separated into 3 size fractions by centrifugation: fine clay (< 0.05 μm), intermediate clay (0.05 - 0.2 μm), and coarse clay (0.2 - 2 μm).
X-ray diffraction was used to determine the mineralogy of the phases and we found that the coarse clay fraction on the one hand and fine and intermediate clay fractions on the other hand exhibited contrasted mineralogies. Fine and intermediate clay fractions contained almost exclusively smectite and mixed-layered illite/smectite minerals whereas coarse clays contained also discrete illite and kaolinite on top of smectite and illite/smectite. We carried out CHN elemental analysis to study the C and nitrogen dynamics with time in the different fractions. And synchrotron based spectroscopy and microscopy (NEXAFS bulk and STXM at the carbon K edge of 280 eV, CLS Saskatoon, Canada) was used to get information on the distribution and the chemical speciation of the SOC in fractions with contrasted mineralogies.

Data analysis is still ongoing and full results will be presented at EGU. First results show that the dynamics and quality of the SOC differ in the different clay fractions. SOC decay was greater in coarse clays compared to intermediate clays, SOC in the coarse clay fraction displaying more diversity than in the other fractions. SOC persistence at the multidecadal timescale also seems to be mineral dependent: smectite being more efficient at protecting carbon compared to illite.