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Soil aggregation stabilizes century old pyrogenic organic carbon

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Increasing soil organic carbon contents is amongst the major challenges today for its crucial role in both soil fertility and as a climate change mitigation tool. To this end, our study focuses on pyrogenic organic carbon (PyOC) that has been incorporated in conventionally farmed agricultural soils for over a century. In the topsoil, the studied charcoal hearths store 1.6 times more carbon than the uncharred soils.

Our study aims to understand the effects of the accumulation of century-old charcoal on the soil aggregation patterns and the native organic matter stabilization. As a consequence of physical breakdown and the increase in oxidized functional groups with ageing of charcoal, we postulated that charcoal hearths display greater abundance of aggregates whilst stabilizing charred particles in the smallest fractions. We performed particle size-density fractionation on soil samples enriched in charcoal (OB) and reference soils (REF) classified as Luvisols with a silt loam texture. Our objectives were i) to determine the relative abundance of the 15 physical fractions amongst treatments, ii) to quantify the distribution of carbon content amongst these fractions and iii) to characterize charcoal and native organic matter using differential scanning calorimetry (DSC). DSC investigates the thermal stability of organic compounds allowing to assess the repartition of thermally stable PyOC amongst fractions.

Macroaggregates represent the most abundant soil fraction for both treatments (OB= 47% and REF=40%). The macroaggregate-size was the fraction that accounted most for the greater C content in charcoal hearths. Interestingly, the particulate organic matter fraction (POM) of macroaggregate size (2.3 times higher) and the silt and clay fraction protected within the macroaggregates (1.9 times higher) both displayed greater carbon contents in OB than in REF fractions.

DSC analyses in the different physical fractions showed that although thermal stability of PyOC decreases for smaller fractions, the protected silt and clay fraction within macroaggregates represents the soils biggest PyOC pool. These results suggest that century-old charcoal is stored both as free coarse particles and as fine POM and silt-size aggregates protected in macroaggregates. We conclude that century old PyOC, beyond its intrinsic recalcitrance, is broken down from coarse to fine carbon pools, and is further stabilized by aggregation and organo-mineral interactions thus contributing to a long-term carbon stabilization in conventional cultivated soils.