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Mineral phases involved in C accumulation in tropical soils of Western Uganda

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The Western part of Uganda is located along the Albertine Rift. Much like the better-studied Great Rift Valley, the Albertine region has sustained extensive recent tectonic and geologic activity. These events have created a complex landscape in which young soils developed in relatively recent deposits coexist alongside highly weathered profiles. Within a small geographic area, we have identified young soils still bearing weatherable primary minerals; moderately weathered kaolinitic soils; and highly weathered lateritic soils developed from plinthic material. These soils have sharp contrasts in mineralogy thus allowing us to investigate the interaction of different inorganic colloids with organic C, keeping other factors relatively constant.

In 2015, we sampled 23 soil profiles alongside six catenas representing two different land uses (agricultural and forested) and three contrasting weathering stages (young soils with high-activity clays; kaolinitic soils; highly weathered plinthic soils). We analyzed samples for pH, texture, mineralogy, soil organic carbon, and major elements concentrations. We also selected six profiles for sequential size and density fractionation, with the aim to separate organo-mineral complexes according to their mineralogy. The resulting fractions were then subjected to characterization of the mineral and organic components.

At the scale of the catena, results showed that organic C concentration was strongly correlated to soil texture, mineralogy and geochemistry but varied little across land uses (forest or small-holder farming). This indicated that organic matter accrual and persistence was primarily controlled by edaphic factors and only secondarily by management and vegetation type. Kaolinitic profiles had the least amount of soil organic matter. Relatively young soil had higher amounts while highly weathered plinthic profiles displayed exceptional organic C concentration (12% in the mineral topsoil). This suggests that weathering intensity is not a linear predictor of organic C sorption potential.

Physical fractionation showed that organic matter accumulation in light and occluded fractions was minimal. Mineral sorption accounted for 78% of organic C in the topsoil and 95% of organic C in the subsoil. Coarse fractions (> 8 microns) contained little organic C, independent of whether they were rich in silicates (density < 2.78 g/cm3) or rich in oxides (density > 2.78 g/cm3). This indicated that primary silicates and crystalline oxides had little reactivity towards organic C. On the other hand, fine fractions (< 8 microns) accounted for the bulk of organic C accumulation. The highest organic C accumulation was recorded in siliceous (density < 2.78 g/cm3) fine fractions with significant presence of poorly crystalline oxides, suggesting that intimate clay-oxide associations are key to organic matter accumulation in these soils.