Volcanic inputs strongly influence organic matter content and properties in tropical soils

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Many tropical soils in stable landscapes have undergone extensive weathering. As a result, their mineralogy is dominated by resistant primary minerals (chiefly quartz) and secondary phases such as kaolonitic clays and crystalline iron and aluminum oxides. These minerals are thought to have a relatively low capacity to sorb organic matter (OM) to form organo-mineral complexes, therefore limiting OM accumulation. In strongly weathered soils, OM content is thus typically low and highly susceptible to oxidative losses following soil disturbance.

In this study, we sampled soils at four locations in the Albertine rift region of western Uganda. Contrary to expectations, we found that soils hadhigh organic carbon content (up to 13.8%) and that agricultural soils were not prone to OM losses, compared to undisturbed soils under forest cover. We hypothesized that inputs of volcanic materials "refreshed" soil mineralogy, which could have promoted the accumulation of OM in soils of this tectonically active region.

Although three of the four sampling locations were situated within the volcanic field of Ndale, no trace of volcanic ejecta could be found in the field. Geochemical and mineralogical analyses showed that bulk soil composition was typical of weathered to strongly weathered tropical soils. Petrographic analysis of soil thin sections, however, revealed the presence of small amounts of weatherable mafic to felsic primary minerals. Their origin was most probably recent volcanic ejecta and pulverized basement rock.

The presence of weatherable minerals was positively associated with OM accumulation as well as with the occurrence of high activity (smectitic) clays and poorly crystalline Fe oxides. Density fractionation and selective extraction showed that most of the OM was present as organo-mineral complexes. This suggests that the small proportion of reactive mineralogy present in the soils was sufficient to promote OM sorption to mineral surfaces, even ones considered as non-reactive (such as quartz), by forming coatings.

Altogether, these results show that small amounts of weatherable mineral inputs can significantly alter soil biogeochemical processes, including OM accumulation and chemical fertility. This raises interesting research perspectives as enhanced weathering, which refers to the spreading of powdered mafic rocks on agricultural lands, comes under consideration as a C sequestration technology.

Mots-Clés : Soil organic carbon, African Rift, Ferralsol, Plinthosol, micromorphology, olivine, pyroxene, ferrihydrite, organo-mineral interactions, pyrophosphate, oxalate and dithionite extraction, Rock-Eval pyrolysis