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Organic carbon stabilization controlled by geochemistry in tropical rainforest soils

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Stabilization of organic carbon in soils (SOC) depends on several soil properties, including the soil weathering stage and the mineralogy of parent material. As such, tropical SOC stabilization mechanisms likely differ from those in temperate soils due to contrasting soil development. To better understand these mechanisms, we investigated SOC dynamics at three soil depths under pristine tropical african mountain forest along a geochemical gradient from mafic to felsic and a topographic gradient covering plateau, slope and valley positions. We conducted a series of soil C fractionation experiments in combination with an analysis of the geochemical composition of soil and a sequential extraction of pedogenic oxides. Overall, we found that reactive secondary mineral phases drive SOC properties together with aggregation. These key mineral stabilization mechanisms for SOC were strongly related to soil geochemistry and independent of topography in the absence of detectable erosion processes. We also detected fossil organic carbon (FOC) at several sites, constituting up to 52.0 ± 13.2 % of total SOC stock in the C depleted subsoil. FOC decreased strongly towards more shallow soil depths, indicating decomposability of FOC by microbial communities under topsoil conditions. Regression analysis showed that variables affiliated with soil weathering, parent material geochemistry and soil fertility, together with soil depth, explained up to 75 % of the variability of SOC stocks and $\Delta^{14}C$. Furthermore, the same variables explained 44 % of the variability in the relative abundance of C associated with microaggregates versus free silt and clay associated C fractions. We conclude that despite long-lasting weathering, geochemical properties of soil parent material leave a footprint in tropical soils that affects SOC stocks and links two of the most important mineral related C stabilization mechanisms. While the identified stabilization mechanisms and controls are similar to less weathered soils in other climate zones, their relative importance is markedly different in the investigated tropical soils.