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Carbon stabilization mechanisms in Ecuadorian Andosols

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Volcanic ash soils contain very large stocks of soil organic matter (SOM) per unit area. Consequently, they constitute potential sources or sinks of the greenhouse gas CO_2. Whether soils become a net carbon source or sink upon climate and/or land-use change depends on the stability of SOM against decomposition, which is influenced by stabilisation mechanisms in the soil. To clarify the role of chemical and physical carbon stabilisation mechanisms in volcanic ash soils, we applied selective extraction techniques, performed X-ray diffraction analyses of the clay fraction and estimated pore size distributions at various depths in the top- and subsoil along an altitudinal transect in the Ecuadorian Andes. The transect encompassed a sequence of paleosols under natural upper montane forest as well as grassland (páramo). From several soils SOM was further characterized at a molecular level using GC/MS analyses of extractable lipids and Pyrolysis-GC/MS analyses of bulk organic matter. Our results show that organic carbon stocks under forest as well as páramo vegetation roughly doubled global averages for volcanic ash soils. The carbon stabilization mechanisms involved are: i) direct stabilization of SOM in organo-metallic (Al-OM) complexes; ii) indirect protection of SOM through low soil pH and toxic levels of Al; and iii) physical protection of SOM due to a very high microporosity. When examining the organic carbon at a molecular level, interestingly we found extensive degradation of lignin while extractable lipids were preferentially preserved, hinting at fungal degradation in the face of inhibited bacterial decomposition. Both vegetation types contributed to soil acidification, thus increasing SOM accumulation and inducing positive feedbacks. Most types of land-use change will result in immediate and substantial carbon loss to the atmosphere. Our results stress the urgent need to protect the Tropical Andes ‘hotspot’ from destructive land-use change, not only for the sake of preserving its outstanding biodiversity but also for its function as a carbon sink.