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Carbon stabilization mechanisms in soils in the Andes

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The volcanic ash soils of the Andes contain very large stocks of soil organic matter (SOM) per unit area. Consequently, they constitute significant potential sources or sinks of the greenhouse gas CO_2. Climate and/or land use change potentially have a strong effect on these large SOM stocks. To clarify the role of chemical and physical stabilisation mechanisms in volcanic ash soils in the montane tropics, we investigated carbon stocks and stabilization mechanisms in the top- and subsoil along an altitudinal transect in the Ecuadorian Andes. The transect encompassed a sequence of paleosols under forest and grassland (páramo), including a site where vegetation cover changed in the last century. 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 the transect. In addition, from several soils the molecular composition of SOM was further characterized with depth in the current soil as well as the entire first and the top of the second paleosol using GC/MS analyses of extractable lipids and Pyrolysis-GC/MS analyses of bulk organic matter.

Our results show that organic carbon stocks in the mineral soil under forest a páramo vegetation were roughly twice as large as global averages for volcanic ash soils, regardless of whether the first 30cm, 100cm or 200cm were considered. We found the carbon stabilization mechanisms involved to be: 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 of the soil (Tonneijck et al., 2010; Jansen et al. 2011). When examining the organic carbon at a molecular level, interestingly we found extensive degradation of lignin in the topsoil while extractable lipids were preferentially preserved in the subsoil (Nierop and Jansen, 2009). Both vegetation types contributed to soil acidification, thus increasing SOM accumulation and inducing positive feedbacks. While carbon stocks in the mineral soil were roughly equivalent under forest and páramo vegetation, a significant amount of additional carbon were stored in exceptionally large ecto-organic layers of up to a meter thick under forest vegetation that are absent under páramo.

In our presentation we will further elaborate these results and place them in the context of SOM turnover under climate and/or land-use change in the broader Andean region, including a comparison with SOM dynamics in non-volcanic soils as present in the Peruvian púna systems.

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