

Can we comprehend organo-mineral associations occurring at different levels of soil aggregate hierarchy? A case study using a volcanic-ash soil (Andisol)

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Organic matter (OM) in soil is subject to both microbial transformation and interaction with soil minerals, during which soil aggregates are formed at the spatial scales of nano to mili meters. Due to the variations in mineral and OM compositions as well as the nature of the interaction between the two, organo-mineral particles or aggregates have a range of size and density. Physical fractionation is an effective approach to study organo-mineral interaction and the factors controlling the storage and turnover of soil OM. However, it remains unclear how the findings from fractionation studies are related to the concept of aggregate hierarchy (e.g., larger aggregates are maintained by transient binding agents while smaller ones are held together by more persistent binders). Here we present three studies that use the fractionation approach to examine how short- and long-term soil OM dynamics are linked to the hierarchy concept using Japanese volcanic-ash soils that is known for strong aggregation and OM stabilization capacity.

First, we demonstrated that the isolation of low-density fraction, a readily accessible OM outside of aggregates, was necessary to examine the factors controlling decomposition temperature sensitivity. Second, using sequential density fractionation, we isolated soil aggregates that are resistant to mechanical shaking and showed density-dependent changes in the chemistry of OM ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{14}\text{C}$ as well as C:N ratio) and that of mineral phases (organically complexed metals and short-range-ordered minerals). Third, we found the particle size dependent changes in organo-mineral chemistry in the same soil only after achieving maximum dispersion of these aggregates by sodium saturation followed by sonication. Clay-sized particles after the dispersion, however, still showed aggregated features by SEM and TEM. We will discuss possible factors controlling OM stabilization in these fractions and the presumed relationship between the fractions obtained from different levels of aggregate hierarchy (sonication-resistant particles vs. shaking-resistant aggregates).

Keywords: soil carbon, microstructure, organo-mineral interaction