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Nature of organo-mineral interaction in volcanic-ash soil. Par II. Particle size and aggregate hierarchy

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Soil organic matter (SOM) is the largest carbon pool of terrestrial ecosystem. Stabilization of SOM is largely controlled by interaction of organic matter (OM) and soil minerals. Volcanic-ash soils are characterized by a high SOM content and consist mainly of short-range-order minerals such as allophane, imogolite and ferrihydrite. Allophane/imogolite are unique nanoclays of hollow spherule/tube structures with the diameter of <5 nm and have extensive, variable-charge surfaces. Due to the dominance of these nanoclays, SOM stabilization process in volcanic soils may differ drastically from that in non-volcanic soils consisting of well-crystalline minerals. Particle-size fractionation is an effective approach to distinguish different types of organo-mineral associate. These nanoclays form stable micro-aggregates and are difficult to disperse, which makes the effectiveness of this approach obscure. Here we hypothesized that, with an appropriate dispersion technique, major portions of SOM is stabilized in finer size fractions (<2 micro-m) as sub-micron aggregates of short-range-order minerals with microbially-processed organic matter in volcanic-ash soils. To test this, we chose a typical allophanic Andisol in Japan and characterize each particle-size fraction by selective-dissolution, isotopic (N-15, C-13, C-14), and spectroscopic techniques. Results showed that: (i) total organic carbon and nitrogen were mainly stabilized in finer size fractions (<2 micro-m), (ii) <0.2 micro-m and 0.2-2micro-m sized fractions largely consist of the association between OM and short-range-order minerals, (iii) the decline of C:N ration and enrichment of N-15 towards finer fraction indicate that the OM in finer-sized aggregates appeared to be more strongly altered by soil microbial activity. Based on these results, we attempt to provide a speculative synthesis on the progression in organo-mineral associations and the development of aggregate hierarchy in the volcanic-ash soil.

Keywords: soil organic matter, organo-mineral associate, particle size fraction, allophanic soil, carbon stabilization