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Quantifying aggregate structure of contrasting carbon levels in Andisol by synchrotron-based X-ray microtomography

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Turnover of organic matter (OM) is regulated by soil aggregate structure via its control on oxygen diffusion, water movement, and accessibility of microbes and enzymes to OM. Yet we have quite limited knowledge on the localization of OM and pore in 3-D aggregate structure. In this study, we focused on volcanic soil (Andisol) because this soil type has (i) the highest OM sequestration potential (except for Histisol and Gelisol), (ii) very high physical aggregate stability, and (iii) very small mineral particles (nano-order, short-range-order minerals such as allophane and imogolite) as main building blocks. We thus took advantage of the high spatial resolution of synchrotron-based X-ray microtomography (X-ray CT) technique and studied the effects of two tillage practices (conventional tillage; CT and no-tillage with compost addition; NT) on intra-aggregate contiguity relation of solid, OM, and pore, visualization of OM and pore and pore characteristics with subtraction imaging of osmium (Os) stained.

We collected soil samples (Andosols) in a long time experimental field in central Japan. The bulk soil was separated to 250-1000 μm size fraction (macroaggregate) by wet sieving. Each macroaggregate was embedded in agarose, OM was stained with osmium tetroxide, and then gradually dehydrated by a series of ethanol solution followed by epoxy resin. Resin-embedded samples were cut to fit for the X-ray CT analysis using synchrotron radiation at SPring-8, Japan. We acquired tomographic images with X-ray energies just above and below the absorption edge of Os.

The Os-stained zones were observed as larger globs with higher brightness in NT whereas those in CT were present as much small patches with low brightness. Pores below three μm were were analyzed and we found rather similar pore characteristics between CT and NT. By selecting several 2-D sections from each aggregates, we are also assessing the proximity of Os-stained OM to mineral matrix vs. pore. We will present these results and discuss the implication for soil OM management and the C dynamics at aggregate scale.