Comparison of allophanic soils of contrasting carbon contents induced by agricultural management: organo-mineral interaction, carbon mineralization, and it's temperature sensitivity

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Volcanic-ash soils hold significant amounts of organic matter (OM) largely because inorganic constituents unique to such soil (e.g., poorly-crystalline minerals and dissolved aluminum) have high capacity to stabilize OM. Better understanding of stabilization and destabilization processes is critical to effectively manage volcanic-ash soils for C sequestration and fertility.

Here we focused on an allophanic Andisol from a long-term experimental field (Tsukuba, Japan) and compared three soil samples (Ap horizon) of contrasting OM contents that resulted from agricultural practices. NT soil was from the plot under no-tillage plus leaf-manure addition for two decades and had 10% total C. NT soil was separately sampled for 0-5 and 5-20 cm due to clear change in soil structure and color. CT soil (5% C) was from conventional tillage with no manure. BA soil (4% C) was from a bare plot which had almost no OM input in recent years.

One-month lab incubation showed that the amount of respired C as well as the percent of total C respired increased in the following order: BA < CT < NT 5-20cm < NT 0-5cm, showing that the pool size of labile C positively correlated with that of soil total C. Density separation revealed that samples with lower total C contents had greater proportions of total C in higher-density fractions (presumably stabilized via organo-mineral interaction).

Based on simple enzyme kinetic theory, we expected that temperature sensitivity (Q_{10}) of soil C mineralization progressively increase from NT to CT to BA based on the OM distribution of labile low-density fraction and more stable high-density fraction among the soils. Estimated Q_{10} from 25 vs. 35˚C incubation showed the highest Q_{10} for BA soil. The rest of soils, however, had similar Q_{10} values despite 3-fold difference in total C and 9-fold difference in respired C among them. These results suggest non-linear response of Q_{10} to soil C pool size and warrant more detail assessment of the temperature control on soil C dynamics.